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OILANDSCAPES.

Coupling ecological and social dimensions with oil infrastructure in Adriatic-Ionian region

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abstractitaliano

Il rapporto tra *energia* e *paesaggio* sta assistendo ad un cambiamento epocale in quanto il modello di produzione energetica centralizzato sta per essere soppiantato da un modello territorialmente distribuito. Accettando questo punto di vista, le "cattedrali della modernità" della produzione energetica della seconda rivoluzione industriale (Branzi, 2006) vedranno il loro ruolo territoriale completamente compromesso.

Alla luce del ruolo delle infrastrutture dei combutibili fossili nella definizione delle gerarchie territoriali e urbane e in vista della transizione energetica prevista dalla terza rivoluzione industriale di Rifkin (2011), la ricerca riconosce nelle connessioni fische diffuse delle *reti del petrolio* (*oil meshes*) il vero potenziale che la riconversione delle *infrasrutture del petrolio* (*oil infrastructure*) potrebbe mettere a disposizione della ristrutturazione territoriale incipiente. Superando la nozione di *infrastrutture del petrolio* e accettando la visione sistemica delle reti del petrolio, la ricerca vuole definire scenari innovativi di sviluppo territoriale che integrano una dimensione socio-ecologica con il campo del progetto delle infrastrutture, definendo così il nuovo ruolo degli **OIL**AND**SCAPES**.

La ricerca attraverso il progetto è la metodologia scelta per indagare la rete del petrolio della pianura padana nord-orientale, utilizzando il mapping e la costruzione di scenari come strumenti per immaginare e valutare futuri plausibili.

abstractenglish

The relationship between *energy* and *landscape* is witnessing an epochal change because the centralized production system is moving towards a distributed territorial one. From this point of view, the "cathedrals of modernity" for energy production of the second industrial revolution (Branzi, 2006) will see their territorial role completely compromised.

In the light of the role of fossil fuels infrastructure in the definition of territorial and urban planning hierarchies and in view of the energetic transition foreshadowed by Rifkin's third industrial revolution (2011), the research looks at the widespread physical connections of oil meshes as the real potential that an oil infrastructure's reconversion could share for the forthcoming territorial restructuring. Overcoming the notion of *oil infrastructure* and embracing the systemic vision of *oil meshes*, the research wishes to define innovative territorial development scenarios, which integrate socio-ecological realms to infrastructural design domain, thus outlining the new role of **OIL**AND**SCAPES**.

Research by design is the methodology chosen to investigate the oil mesh of the north-eastern Po Valley region, using mapping and scenario-building tools in order to imagine and evaluate spatial futures.

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PART I

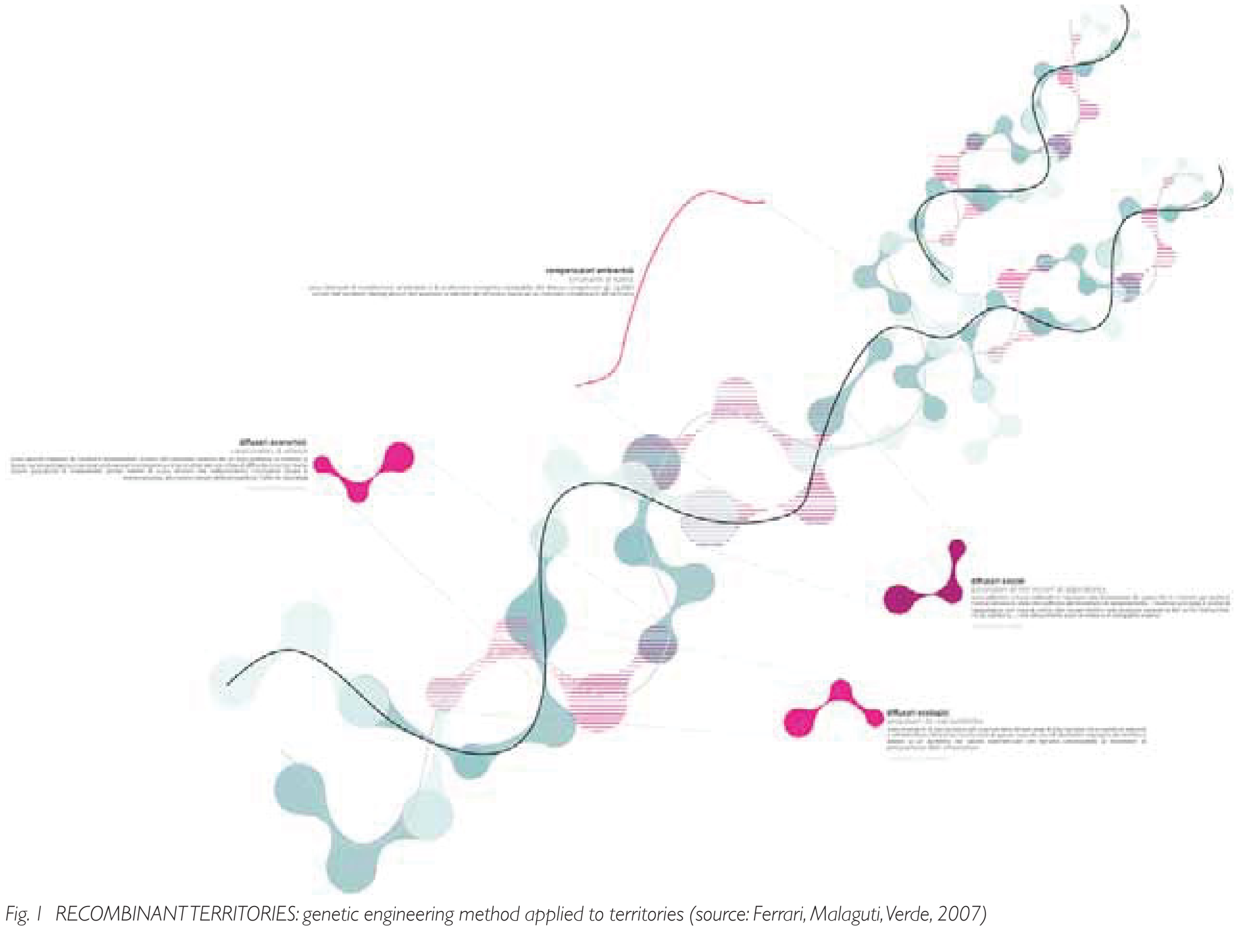


Fig. 1 RECOMBINANT TERRITORIES: genetic engineering method applied to territories (source: Ferrari, Malaguti, Verde, 2007)

Scope of the research

Fascination for the subject

previous research experiences

Our interest in the field of research that investigates the multi-scalar relationship between *energy* and *landscape*, both understood in their infrastructural sense, dates back to 2007, on the occasion of the project developed for the Master Degree thesis in Architecture at the University of Ferrara (Italy).
The research *RECOMBINANT TERRITORIES. Inertia and potentialities in the territories with low anthropic load crossed by corridor 5*[1] focused on the structural changes that European territories with a low population density and crossed by the Trans-European corridor 5 (Lisbona-Kiev 4587 km) would have suffered while awaiting its completion by 2030 and if they could have been prepared in advance to absorb *pump effect and tunnel effect*[2].
Taking as a case study the sparsely inhabited territories surrounding the Lisbon-Madrid tract, precisely in Extremadura region, the research proposed to interpret *tunnel effect* territories as *environmental compensators*, that is to say as protected ecological reservoirs where to implement some strategies for an environmental mitigation of the economic growth in *pump effect* territories through *renaturation activities* and *renewable energy production* along a buffer zone parallel to corridor 5. The objective was to compensate for environmental imbalances, while creating green jobs in areas at risk of demographic and ecological impoverishment.

1 The original title of the Master Degree Thesis is *TERRITORI RICOMBINANTI. Inerzie e potenzialità nei territori a basso carico antropico attraversati dal corridoio 5.* Academic year: 2006–2007; Graduates: Matteo Ferrari, Anna Malaguti, Alberto Verde; First Supervisor: Prof. G. Franz; Second Supervisor: Arch. M. Bonizzi; Score obtained: 110/110 with honours.

2 *Pump effect* describes the demographic, employment and economic centralization impact due to the new possibilities provided by the settlement of a high-speed railway station of corridor 5 in medium-sized urban centres and the consequent connection to a wider economic system.
Tunnel effect refers to the impermeable impact of the new infrastructure on crossing a territory without bringing any improvement and economic growth to the surrounding territory.

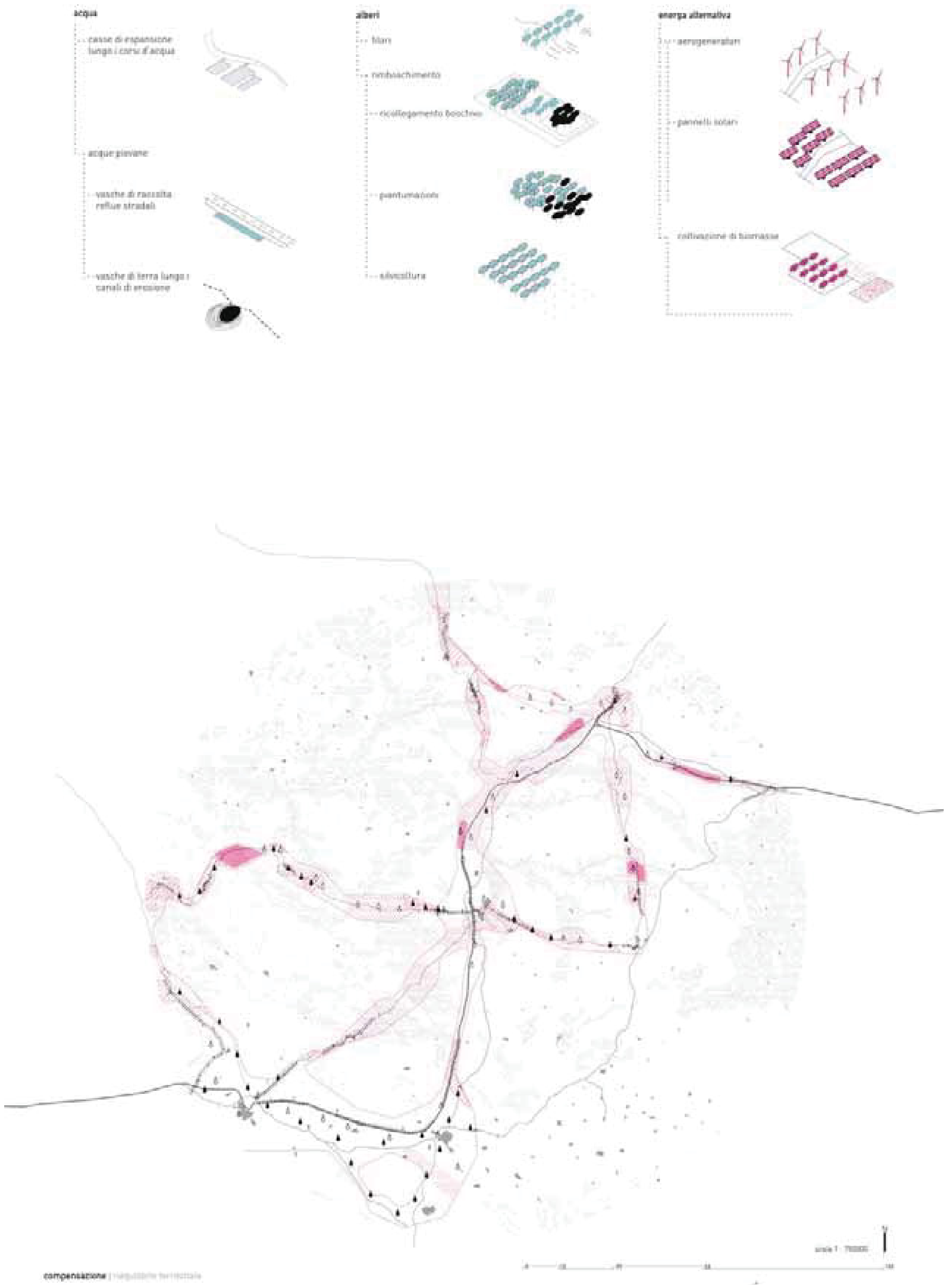


Fig. 2 RECOMBINANT TERRITORIES: environmental compensators in Extremadura (source: Ferrari, Malaguti, Verde, 2007)

photography

Further considerations about the relationship between *energy production* and *landscape* have been fueled by a personal passion for photography.
The fascination for the photographic work about the visual component of the industrial prevarication over the environment carried out by the Canadian photographer *Edward Burtynsky* allowed us to broaden the horizons of the research. In his books *Oil* (Burtynsky, 2009) and *Manufactured Landscapes* (Burtynsky, 2003) the photographer reflected on the devastating consequences that the anthropocentric attitude of the western world, focused on satisfying human being's needs as its ultimate aim, has generated to the detriment of Nature.
The artist's statements below helped us to clarify in what visual and spatial terms this conflict has manifested itself on the territory and, subsequently, has led us to narrow the field of the research questioning the impact that *oil energy infrastructure*, in all its forms and expressions, have had on landscapes:

> *"When I first started photographing industry it was out of a sense of awe at what we as a species were up to. Our achievements became a source of infinite possibilities. But time goes on, and that flush of wonder began to turn. The car that I drove cross-country began to represent not only freedom, but also something much more conflicted. I began to think about oil itself: as both the source of energy that makes everything possible, and as a source of dread, for its ongoing endangerment of our habitat.*
>
> *I wanted to represent one of the most significant features of this century: the automobile. The automobile is the main basis for our modern industrial world, giving us a certain freedom and changing our world dramatically. The automobile was made possible because of the invention of the internal combustion engine and its utilization of both oil and gasoline. The raw material and the refining process contained both the idea and an interesting visual component for me."*
>
> (Edward Burtynsky, source: www.edwardburtynsky.com/projects/photographs/oil)

Oil infrastructure stands for automobiles, which is synonymous with the unprecedented development of the motorway infrastructure network that spread thanks to the consolidation of the oil itself as the main energy source with the advent of the second industrial revolution.
Thus, the field of the research extends to *urban studies* because it is evident that, depending on the type of energy source, there is a tight and invisible bond among energy infrastructure and the development of specific mobility infrastructure, the sum of which has contributed to the emergence of *new urban forms.*

Fig. 3 Alberta Oil Sands #2, Fort McMurray, Alberta, Canada, 2007 (source: Edward Burtynsky)

Fig. 4 Alberta Oil Sands #6, Fort McMurray, Alberta, Canada, 2007 (source: Edward Burtynsky)

cinema

Once identified the previous equation that indissolubly links the impacts of oil energy production with, on the one hand, landscape and with, on the other one, new forms of living in the city, the cinema's contribution to a more precise definition of the fundamental debates cannot be neglected, shifting the attention to the social repercussions related to the arrival of that huge oil infrastructure in Italy. Famous is the neo-realist film *Deserto Rosso* (1964), the first colour film made by Michelangelo Antonioni, whose scenes take place in Ravenna, some of them in its industrial port precisely when, between the 1950s and 1960s, the port began to experience a wild industrialization process made up of petrochemical plants and of a polluting thermoelectric power plant.

The phenomenon of industrialization is represented as something stranger to the local context, which occurred in too short a time to be metabolized by local people and completely out of scale with respect to the essentially backward reality of Ravenna, still based on a prevalently local fishing economy.

The territorial degradation is evidenced by the replacement of the typical fishing huts hanging along the canal port with the huge petrochemical complex. This sudden transformation is emphasized by sound and visual effects, such as the choice of lingering a long time on the disturbing sounds generated by industrial activities and the choice of eliminating every shade of blue from the sky, in favour of a blurred grey effect which seems to recall illness and death, except for the vivid colours used to denounce polluting emissions.

The new rhythm of the industrial life which follows an exasperate competitive model and the consequent loss of traditional values generate a temporal discrepancy in the private life of local people, leading to psychological disorders and depression. The protagonist of the film, played by Monica Vitti, suffers from these psychic disorders, which cannot even be solved through her continuous attempts to escape from a private sphere that seems to oppress her. This works as symbol of a widespread malaise in front of a technological and thinking change, that society was not yet ready for, but which is structural and can no longer be rejected. The acceptance and coexistence with the uncomfortable condition seems to be the only solution proposed to a society facing those epochal changes and the protagonist, at the end of the film, does the same when she decides to accept the decides to do in relation to her not curable depression.

research question

Leaving the emotional suggestions from the paragraphs above and focusing on the impact of oil energy infrastructure for environmental and social conditions, a question is to be answered to remedy wounds in the territory:

is it possible to think of a new role in the definition of territorial hierarchies for oil infrastructure once it has been deprived of its original function as a consequence of its decommissioning due to the energetic transition?

Fig. 5-6-7 Frames from the film "Deserto Rosso" (1964) by Michelangelo Antonioni: Ravenna's petrochemical landscape

Subject of the scientific research

the energy crisis of 1973

What is known globally as the *energy crisis of 1973* represented somehow an epoch-making moment of radical changes in the global economic model. For the first time since the beginning of the first industrial revolution this event profoundly influenced the common awareness about the instability of the productive and energy system and put into crisis a model consolidated in more than 150 years of energy dependencies. But let us proceed step by step, and firstly try to understand the political and economic framework in the early 1970s that led to this break-up.

The *Kippur war*, which saw the armed forces of Egypt and Syria opposed to those of Israel for twenty days from October 6,1973, represents the tip of the iceberg and the geopolitical expedient that justified a much more complex economic situation, made up of conflicts among majors oil companies, independent oil companies and OPEC (Organization of the Petroleum Exporting Countries) that had persisted since the early 1960s. The decision of the OPEC-associated Arab countries to support Egypt and Syria's action through robust barrel price increases and embargoes against the most pro-Israeli countries does not fully describe the oil market situation in the early 1970s.

According to Petrini (2012), three main dynamics led to a weakening of the system of governance of the oil market built by the majors oil companies[1] after World War II:

- the desire on the part of exporting countries for greater control of their natural resources, which matured in 1960 with the establishment of OPEC;
- the majors' oligopoly crisis caused by the entry into international oil market of new independent players (especially for oil extraction in the Middle East);
- the changing relationship between supply and demand on the crude oil markets.

Petrini identifies in the reduction of the profitability of oil industry, mainly due to the saturation of the markets and their structural change, the principal reason for the crisis of the oligopolistic system. This mechanism managed from 1948 to 1973 a demand expansion that increased more than six times and that, as pointed out by Maugeri (2006), has been the longest and most stable phase of low prices ever experienced by the oil industry. The oil extraction price increase

1 It is attributed to Enrico Mattei, at the time Commissioner appointed by AGIP for the liquidation of the Italian public oil company in 1945, the invention of the expression *Seven Sisters* to describe the oil companies that dominated the world's oil production from the 1940s until the energy crisis of 1973. The *Seven Sisters* included: Standard Oil of New Jersey (since 1973 called Exxon), Standard Oil of New York (then called Mobil), Gulf Oil, Standard Oil of California (since 1984 called Chevron after the fusion with Gulf Oil), Texaco, Anglo-Persian Oil Company (then called British Petroleum) and Royal Dutch Shell.

from depleted deposits in the United States and the incentive to explore for new reservoirs abroad[2] led the Seven Sisters to concentrate their extractive activities in the Middle East, where production costs were significantly lower. This system ensured for a while high profits for the Seven Sisters and low prices for consumers.

Actually, things went differently: between 1954 and 1970, a significant fall in the price of Arab crude oil caused by the overabundance of supply on the oil markets was registered. Demand grew considerably, but production increased at an even faster rate. From Petrini's essay (2012, p. 453), in fact, it is possible to extrapolate some very interesting historical data that have been retrieved by authors such as Parra and Adelman: between 1950 and 1970, in front of a quadrupled world demand for oil, production in the Persian Gulf increased from 1.8 million barrels per day in 1950 to 14 million barrels in 1970, just as Russia increased its production from 750 thousand to 7 million barrels per day.

Therefore, oil markets faced the decade of 1970 disturbed by the simultaneity of the three political and economic dynamics already anticipated, that is to say a significant reduction in prices due to overproduction that was no longer able to be absorbed by demand, the expansion of the Middle East extraction scene also to independent oil companies and the affirmation of an increasingly important position of exporting countries in claiming a higher return on their natural resources.

Profit margins diminished, so it was necessary to intervene on prices for consumers who were still benefiting from the low and stable prices
as during the oligopolistic period.

It was in that period that the longevity of oil reserves began to be questioned: if consumption had maintained the same growth rate, how many decades would oil reservoirs last? The common feeling of an overabundance in oil resources turned into fear because oil started to be perceived as a finite resource. The whole industrial and energy system operated around oil and fear for its scarcity caused a drastic increase in the price. According to Parra[3], the major oil companies themselves contributed to fuel the panic about the scarcity of oil reserves.

In addition, Middle East countries understood their contractual power, being the owners of the most easily reachable and lowest-cost exploitable oil reserves. In this framework the Kippur war must be contextualized, allowing Arab OPEC countries to increase the cost of the royalties.

The increase in production prices together with the intention to maintain high profits by oil companies meant that higher costs were completely passed to oil importing dependent countries.

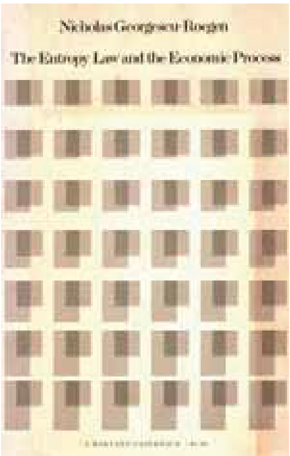
2 The initiative was supported by a tax exemption for profits generated by foreign oil extraction activities promulgated by the US Congress in 1951.

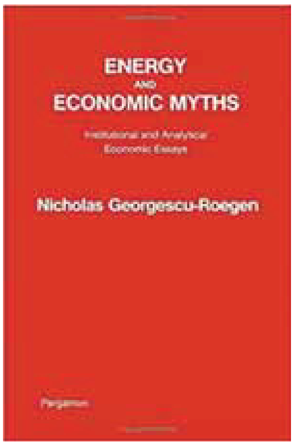
3 See Parra, F. (2004). Oil Politics. A Modern History of Petroleum. London: Ib Tauris.

It was in the wake of the energy crisis of 1973 that debates about limiting the dependence on the oil supply from foreign companies through energy savings and through national energy policies began to appear.
If we think of the Italian panorama, the country's energy independence was the objective that Enrico Mattei wanted to achieve from the beginning of the 1950s. For this reason, although Italy was not rich in oil, Enrico Mattei decided to make considerable investments in methane exploration and extraction from the Po plain, as well as for the implementation of national gas infrastructure. The gas backbone that crosses Italian territories from north to south parallel to the Apennines and that connects Italy to the continental gas markets of eastern Europe and to the intercontinental one to the south, towards North Africa, is precisely due to Enrico Mattei's utopia of a *continental energy strategy*[4].

ecological conscience

It is not a coincidence if an *ecological conscience* began to spread in the 1970s, questioning the simulacra of the industrial growth and opening up to *ecology*[5] as an essential discipline to be integrated within social and economic sciences for the pursuit of a sustainable development. In a chronological order, we would like to mention some of the key milestones that have led to the consolidation of an ecological thinking:



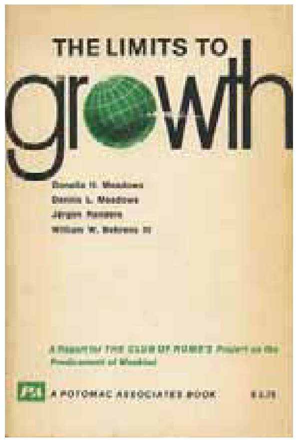


- in 1971 the book *The Entropy Law and the Economic Process* written by the Romanian economist Nicholas Georgescu-Roegen was published and laid the basis for the further implementation of *bioeconomy*[6] theory.
An essay of 1970 named *The Entropy Law and the Economic Problem*, published in 1976 as part of a collection of Georgescu-Roegen's essays, offers us a key statement in order to interpret his position that indissolubly links economic sciences to the Second Principle of Thermodynamics:
"An unorthodox economist—such as myself—would say that what goes into the economic process represents *valuable natural resources* and what is thrown out of it is *valueless waste*. But this qualitative difference is confirmed, albeit in different terms, by a particular (and peculiar) branch of physics known as thermodynamics. From the viewpoint of thermodynamics, matter energy enters the economic process in a state of *low entropy* and comes out of it in a state of *high entropy*" (Georgescu-Roegen, 1970, p. 53–54).
In his visionary theory, Georgescu-Roegen argues that the Second Principle of Thermodynamics, according to which entropy is a non-decreasing function over time and we therefore observe a degradation of energy quality at the end of each process, is valid for any science that

4 See https://www.eniday.com/it/education_it/europa-enrico-mattei/
5 Ecology is considered the study of relations between organisms and the environment.
6 Bioeconomy is an economic theory for an ecologically and socially sustainable economy.

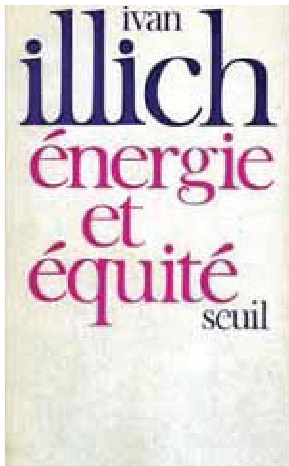
deals with the future of the human being, including economic sciences. Any economic process that produces material goods decreases the energy availability for the future and thus the possibility of producing other goods and material things. Economic science must therefore be reconsidered in order to incorporate the principle of entropy and of ecological constraints;

• in 1972 the famous *The limits to growth* (Meadows et al., 1972) report appeared. The report was commissioned in 1968 by the Club of Rome[7] to MIT and it consisted of a document that highlighted for the first time how the economic growth could not continue indefinitely growing due to the limited availability of natural resources (including oil) and the limited capacity of absorption of pollutants by the planet. Using the methodology of scenarios simulations, the text considered five variables that allowed to measure the impact that human activities could have on the Earth, that is: *population, industrialization, pollution, food production and exploitation of resources*. In summary, two of the scenarios elaborated by the computer World3 showed how the exponential growth of the five variables according to the rates of that time would have led to a collapse scenario, reaching physical limits due to the lack of natural resources and to the planet's inability to regenerate itself by the middle of XXI century. A third scenario highlighted how, reducing growth rates, a condition of *ecological and economic stability* could be achieved, guaranteeing a sustainable development even in the long term. A global equilibrium should be designed in order to guarantee that the needs of each person on Earth are satisfied, and everyone has equal opportunities to realize its human potential;



• another relevant publication appeared in 1973 which consolidated the convictions about the risks of reaching a state of social inequity due to industrialization processes and energetic overabundance is *Energy and Equity* by Ivan Illich (1973). Interesting is the author's approach, which measures the well-being of a society through its type of energy use, identifying three possible orientations:

- well-being as a strong energy consumption per capita;
- well-being as high efficiency in energy transformation;
- well-being as the least possible use of mechanical energy.



According to Illich, the only way forward that can guarantee a fair future for our society is the third one, that of limiting mechanical energy. Energy and equity have a threshold beyond which inequality develops. In fact, not all people can have access to energy-intensive activities: the increase

7 The Club of Rome is a non-governmental, non-profit association of scientists, economists, businessmen, civil rights activists, senior international public leaders from all five continents. Its mission is to act as a catalyst for global change, identifying the main problems that humanity will face, analysing them in a global context and seeking alternative solutions in different possible scenarios (see https://it.wikipedia.org/wiki/Club_di_Roma).

of energy consumption imposed by industrialization forces the use of "dominant" instruments, which can only be purchased by those who have the necessary economic resources, to the detriment of "convivial" ones, which are instead democratically available to everyone.
This inequity clearly emerges in the use of transport: car consumes a great deal of mechanical energy during its production, during its use and is not a good accessible to everyone. Moreover, speed search is a fake myth, as it creates greater distances and it forces people to travel along them, requiring more and more travel time. The increase in distances obliges people to own a car, which occupies space and therefore creates traffic congestion, thus increasing the loss of time and drastically reducing the convenience associated with the hypothetical reduction in travel times. Illich therefore believes that, in order to combat the energy crisis, it is necessary to set limits and identify a threshold beyond which negative effects and iniquity are going to be generated, starting with the transport domain. Illich identifies in 25 Km/h the threshold for transport equity, that is to say the speed of a bicycle that moves with the metabolic power produced by human beings' work, the only fair and non-polluting energy.

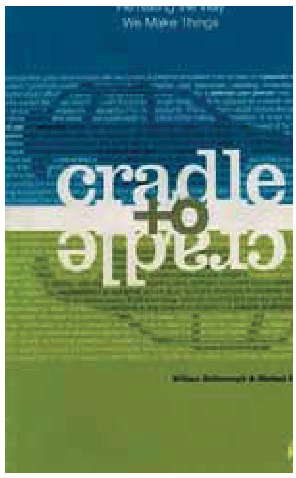
• in 1977 André Gorz published his work *Écologie et Liberté*, introducing the notion of *ecological realism*. According to him, contemporary society must be aware that capitalist economic growth based on overproduction has failed, not guaranteeing the promised well-being in an equitable way and creating new forms of crisis among society, economy and nature. Recalling bioeconomy's theory proposed by the economist Georgescu-Roegen and sharing with him the assumption that natural resources are limited, Gorz stated that future developments must be able to manage the preservation of natural resources for the future generations, thus consuming less.
In this text Gorz used for the first time the term "degrowth" which was later taken up, starting from Georgescu-Roegen until Serge Latouche, to describe a current of political, economic and social thought in favour of a controlled, selective and voluntary reduction of economic production and consumption, with the aim of establishing balanced relations between man and nature.
The ecological thought arose when people became aware that natural resources were not inexhaustible and that economy, in order to overcome a "relative scarcity", generated an "absolute scarcity" destroying those natural resources that the human being was no longer able to regenerate (Gorz, 1977, p. 23). Quoting Illich[8], Gorz argued that the increase in production would have led to a worsening condition of scarcity and would

8 About Counterproductivity, see Illich, I. (1975). Némésis médicale. Paris: Le seuil. pp.83-100.

have generated "counterproductivity".
The way of limiting or reducing the material production could be pursued through two different models:
- through *conviviality*, that is to say by applying limits to institutional production guaranteeing the conservation of natural resources, preserving natural balances and giving a greater autonomy to local communities;
- through *techno-fascism*, which means applying technical engineering solutions to living systems.
According to Gorz, an alternative culture to the capitalist one would be possible only by pursuing the convivial option and placing *ecology* as the foundation for a new society capable of transforming productive technical methods to more respectful practices for the living environment.

the circular economy

The excursus among the previous texts shows how they influenced each other and how they contributed in the consolidation of a critical conscience that placed *ecology* at the centre of attention.
The strength of the previous works lies in their radicalness and in the disruptive effect that they had at the time: although some positions were deliberately extreme, they provided an innovative theoretical basis that allowed to open new debates that continued over the decades.
It seems evident how the circular economic and productive model exposed in 2002 in the book *Cradle to Cradle. Remaking the Way We Make Things* written by McDonough and Braungart refers to and is inspired by the ecological thinking of the 1970s.



Their initial assumptions put at the centre of the reflection the necessity to change the industrial production and design approach. The current "cradle-to-grave" model, based on the production of goods that, once they have reached the end of their life cycle, they are thrown away or downcycled for lower quality uses, is no longer sustainable, as it requires an immense waste of natural resources and generates a lot of waste and pollution.
As suggested by the title of the book itself, their proposal consists in moving to a "cradle-to-cradle" model. The expression stands for a sort of industrial revolution which no longer looks at the linearity of *eco-efficiency* flows, but rather seeks a circular transformation of products and of their material flows in terms of *eco-effectiveness*, in order to preserve and enhance the biological cycles, while maintaining productive cycles. *Upcycling,* understood as creative reuse, is therefore the theoretical position proposed by the model, according to which it is possible to transform by-products into new materials or products with a higher quality or a better environmental value.

During the process of adapting production models to the nature, the intuition of the authors consists in assimilating used materials to natural elements, envisaging the possibility to consider them as resources to be upcycled in *biological nutrients* or in *technical nutrients*. Materials included in *biological nutrients* will be able to return to the environment without contaminating it with toxic and polluting substances, while others will continue to circulate as valuable *technical nutrients* in closed industrial production cycles.

energetic transition

In this visionary context of integrating ecological and social dimensions to an economic model that would support the creation of environmentally compatible productive systems, the *energetic transition* towards renewable energies becomes a pivotal element for its fulfilment.

This massive shift towards the production of clean energy is above all an economic, political and cultural issue. Indeed, we will not switch to renewables because of oil or fossil fuels shortages.

The *peak oil* theory advocated by Marion King Hubbert[9] in 1956 has been repeatedly criticized and questioned. In fact, the theory envisaged the possibility of predicting, through geological and statistical data about historical extraction rhythms, when the so-called *Hubbert peak oil,* corresponding to the maximal oil production, would have been reached. From that moment onwards, the decline of oil production would have started as the costs for its extraction would have exponentially increased.

The detractors of peak oil theory asserted that it was ignoring social and technological advances. Even if world oil consumption has increased, exploitable predictable reserves have not decreased due to new more efficient oil production techniques which also extended the extractive scenario (see shale oil and tar sands) and to a broader social environmental conscience (Maugeri, 2012). Thus, oil era will not end because of oil scarcity but because of the development of more convenient energy sources. As to electric energy production, for example, oil has mostly been substituted by natural gas, while it remains the unique significant energy source for mobility industry.

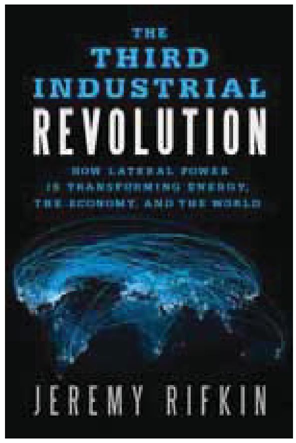
the third industrial revolution

In a broader sense than the revolution of the industrial production system mentioned by McDonough and Braungart (2002), the American economist Jeremy Rifkin (2011) tackles the issue of the transition to a z*ero-carbon economic model* as the main objective of the forthcoming *Third Industrial Revolution*.

The necessity of starting an energy transition that is more respectful of the environment and that would completely disengage us from the dominant models

9 See Hubbert, M. K. (1956). *Nuclear energy and the fossil fuels*. [Online] Available from: http://www.hubbertpeak.com/hubbert/1956/1956.pdf. [Accessed: 14 March 2016].

imposed by the first and second industrial revolution is absolutely central in his arguments.
If the two previous industrial revolutions were set on a vertical and hierarchical economic model, the third industrial revolution should lie on a democratized, distributed and collaborative energetic production system, where everyone produces and shares electricity with other consumers, and multinational energy production companies convert their business in "utility services", so guaranteeing the maintaining and the improvement of the infrastructure network.
Five are the pillars enounced by Rifkin on which the third industrial revolution should lie, and each of them has an energy component:



- decisive shift towards renewable energies;
- transformation of the existing building stock into micro-power plants to collect renewable energies on site;
- deployment of hydrogen storage technology to stock intermittent renewable energies;
- implementation of internet technologies to energetic power grids to achieve an energy sharing grid;
- transition of transport fleet to electric plug-in and fuel-cell vehicles connected on a smart power grid.

It is clearly understood that the consolidation of the third industrial revolution is closely linked to a necessary infrastructural implementation that should become the backbone for a *zero-carbon and sharing economy*. It is precisely at this point that a long-term strategic political vision becomes necessary to embark on the energy transition we are talking about. If we look back to the shift from the first to the second industrial revolution, Rifkin argues that the implementation of the infrastructural upgrade from coal to oil took almost 50 years.
If this length of time was also confirmed for the transition from the second to the third industrial revolution, we could think to use this transition period to prepare out territories to the radical shift, thus generating millions of job opportunities in the green economy all over the world.

third of fourth industrial revolution?

It is probably necessary to proceed with disambiguation in order to better clarify the choice of assuming the framework of the third industrial revolution depicted by Rifkin as the reference context for the following steps of the research. In fact, there is no single globally recognized criterion for defining the number of industrial revolutions that have taken place up to now. As already explored, Rifkin used the *type of energy source* as the main criterion to identify industrial revolutions (coal, oil, renewable energies), implying that there is a tight bond among energy infrastructure, production systems, cities and territories.
Other prominent personalities consider different criteria for defining the

succession of industrial revolutions, and suddenly these can become four instead of three. A remarkable example is represented by the position of Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, according to whom, as the title of his work also testifies, what we are witnessing corresponds to the *Fourth Industrial Revolution* (Schwab, 2016).

According to him, the first industrial revolution can be identified by the massive construction of railways and the invention of the steam engine, which led to the introduction of the mechanical production. The second revolution is characterized by the advent of electricity and mass production thanks to the introduction of the assembly line in the productive system. The third industrial revolution, on the contrary, is situated at the beginning of the 1960s and is called the *digital revolution* since it is generated by the arrival of the computers and then by the spread of the Internet in the 1990s.

Thus, quoting Schwab (2016):

"the fourth industrial revolution creates a world in which virtual and physical systems of manufacturing globally cooperate with each other in a flexible way. This enables the absolute customization of products and the creation of new operating models. […] Occurring simultaneously are waves of further breakthroughs in areas ranging from gene sequencing to nanotechnology, from renewables to quantum computing. It is the fusion of these technologies and their interaction across the physical, digital and biological domains that make the fourth industrial revolution fundamentally different from previous revolutions."

According to Schwab, disruptive technologies represent the main criterion through which classify industrial revolutions. The shift towards the fourth industrial revolution is defined by the possibility to implement technological synergies among different research fields.

In our opinion, Rifkin's approach, which focuses on the role of energy infrastructure for identifying industrial revolutions, results to be more pertinent to our research theme, focusing on territorial hierarchies with industrial areas and inhabited centres and opening up to new planning, landscape and urban debates.

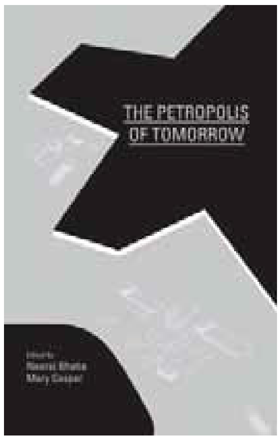
energy and landscape

It is precisely within the framework of the debate between *energy* and *landscape* that our research is intended to fit in.

Previous research has investigated this relationship using different approaches and methodologies, of which we would like to give a few hints:

- *Energyscapes* by Aleksandar Ivancic (2010) describes in a taxonomic form the morphology of the principal "artefacts" related to fossil-fuel energy production, dividing landscape typologies in macro sectors: *search and extraction*, *transformation and processing*, *transportation and storage*. Subsequently,

he deals with the issue of the decommissioning of these large energy production complexes, considering them as "graveyards" and analysing the devastating effects that these ruins still have on the environment once their normal life cycle is over. His research subsequently focuses on some renowned international best practices of mining or energy industrial "recycling", such as IBA Emscher Park, Zollverein Zeche and Tate Modern. Each of them is characterized by the conversion of the original productive and raw materials storage function into a new form of "cultural storage", which foresees the establishment of museum activities to replace productive ones. Industrial rehabilitation for cultural purposes seems to be the only possible future for those abandoned "cathedrals of the modernity" (Branzi, 2006). The research concludes by evoking the "promises" of the energy transition, passing through the horizons of the renewable energy production techniques. First of all, Ivancic refers to the transition towards a diffused electricity "microgeneration" (Ivancic, 2010), which would allow to dismantle the hierarchical and centralized system imposed by the large multinationals of the energy sector. Afterwards, the author explores some innovative energy production techniques, such as those based on algae cultivation, recovery of marine energy, exploitation of free cooling potential and flexible solar fabrics. It should be noted that energy production from algae is considered to be the one with the greatest potential. Ivancic (2010, p.177) reports some data illustrating that an area of about 38'500 km^2 of algae cultivation in open raceway ponds located in high sunshine coefficient territories, corresponding to about 2% of the total agricultural area of the United States, would allow to fully cover with its biofuel production the overall USA transport consumption;



• *The Petropolis of Tomorrow* by Neeraj Bhatia and Mary Casper (2013) is a design-research project that focuses on the extractive oil potential in Brazil. The research accepts the expansion of oil extraction scenarios and investigates how to design through a "holistic approach" an infrastructure that has always been considered as engineering and technical artifacts. Among oil infrastructure, the research specially focuses on the *Petropolises*, that is to say those urban agglomerations univocally linked to oil extraction and settled in order to accommodate the employees of the sector. According to the authors, *Petropolises* must be considered as real cities, and have to be equipped with services, productive agricultural areas, economic activities, even in offshore contexts.

The objective of the research is to seek new urban and architectural forms deriving from a holistic design, which integrate extractive infrastructure with economic, political, environmental and social components;

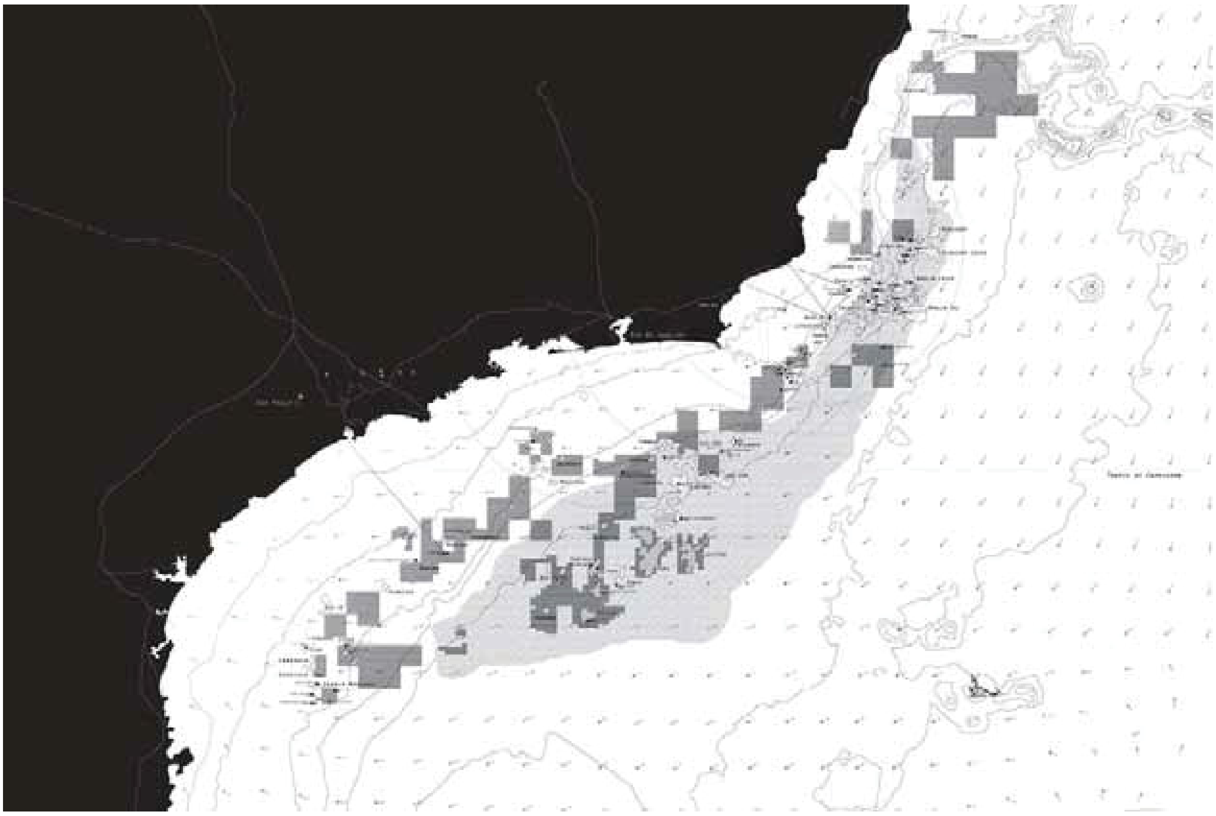


Fig. 8 The Petropolis of Tomorrow: Brazilian oil off-shore extraction (source: Neeraj Bhatia, 2013)

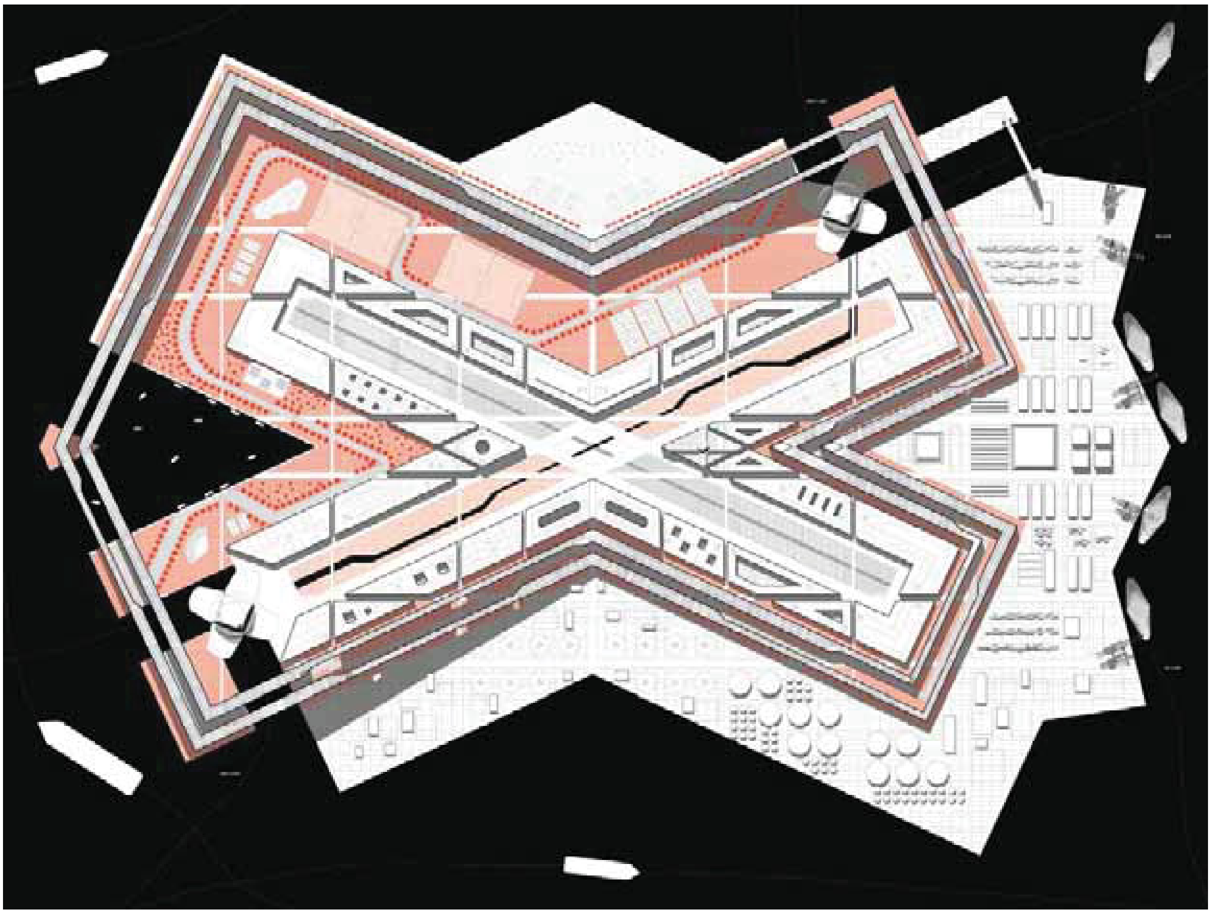


Fig. 9 The Petropolis of Tomorrow: urban form research (source: Neeraj Bhatia, 2013)

• *Landscape and Energy. Designing transition* by Dirk Sijmons (2014) is a multi-scalar design-research project which starts from the assumption that there is reciprocity between *energy* and *space*, because "for every form of energy generation, spatial interventions are required, and every form of energy has a spatial footprint. […] Energy and space change each other, and they change together over the course of history" (Sijmons, 2014, p.10).
Assuming that global warming is already happening because of CO_2 emissions, Sijmons argues that an energy transition to lower CO_2 emission energy production systems is absolutely necessary.
The most interesting and innovative aspect of the research in question is the way it tackles the energy issue at multiple scales of analysis and design. At first, the author wants to define, on the basis of territorial characteristics (average wind speed, solar energy potential, biomass potential, geothermal potential, hydraulic potential), a macro-strategy for the implementation of an infrastructural network for a renewable energy mix at the European level that can achieve an 80% reduction in greenhouse emissions for 2050 if compared to 1990 levels.

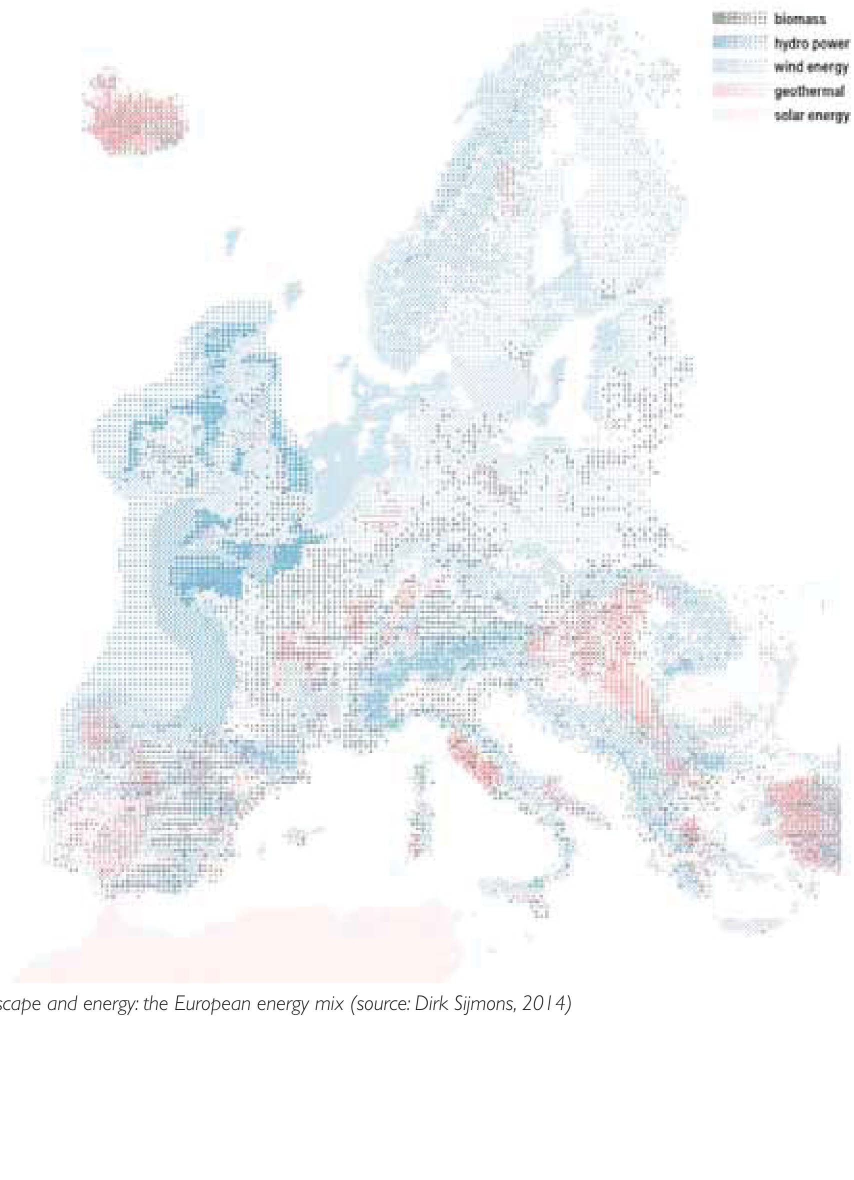


Fig. 10 Landscape and energy: the European energy mix (source: Dirk Sijmons, 2014)

The researcher then analyses the spatial footprint required by every form of energy production, according to the type of energy supplied (electricity, heating, fuels), in order to provide energy for 1 million households in the Netherlands.
The main interest of this approach is to make it measurable and to give the operators an order of magnitude to a phenomenon that, due to technicalities and the size of production capacity, is not at all understandable by non-professionals in the energetic sector. The comparison among different energy production ortho-photos allows the studious to understand the impact of certain energy policies on territories.

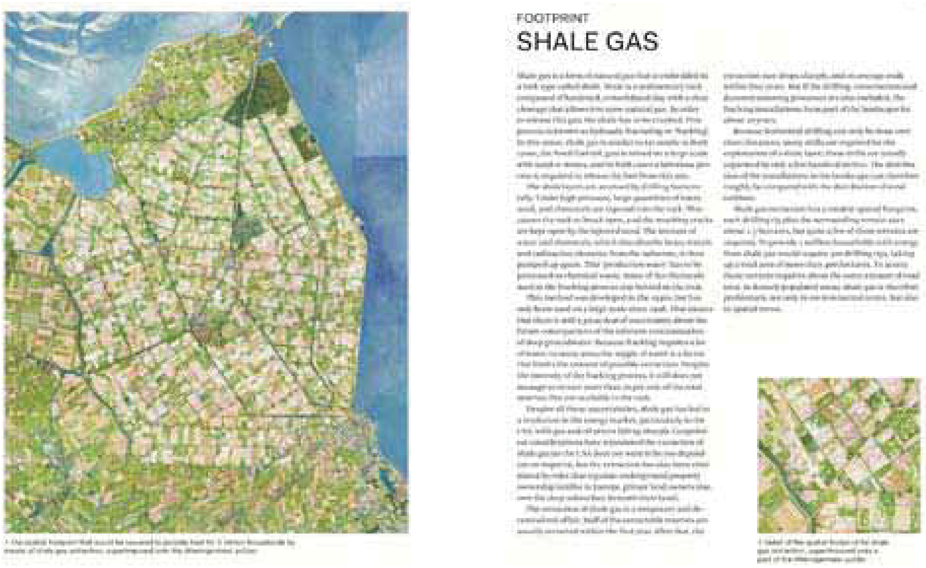


Fig. 11 Landscape and energy: energy spatial footprint (source: Dirk Sijmons, 2014)

Also in this case, the energy potential of algae cultivation is highlighted because of its high calorific value (similar to that of lignite and much higher than that of agricultural biomass) and to its energy efficiency (EROI corresponds to the ratio of energy returned to energy invested in that energy source, along its entire life-cycle), which is more competitive than the extraction of oil from tar sands.
The research then continues by proposing scenarios for spatial development of energy landscapes in some regions of the Netherlands. First, energy landscapes are analyzed in their current and historical configuration, stressing the contemporary dependencies from certain non-renewable energy sources. It is then defined the "renewable challenge" for the territory, setting targets to reduce CO_2 emissions related to existing energy and industrial infrastructure in the territorial case study. The territory is then critically read in order to provide an interpretation of its renewable energy potential (for example geothermal energy, wind energy potential, solar energy potential, residual heat potential if important

industrial platforms are present). Those areas which seem to be more appropriate for the development of these renewable energy scenarios are then identified in spatial terms. The overlapping of the two energy and spatial perspectives allows to propose "spatial energy concepts", that is to say the transposition, through cartographic instruments and three-dimensional spatial suggestions, of how the energy potential responding to the renewable challenge could create new hybrid urban landscapes that merge a mix of energy production with ordinary urban life.

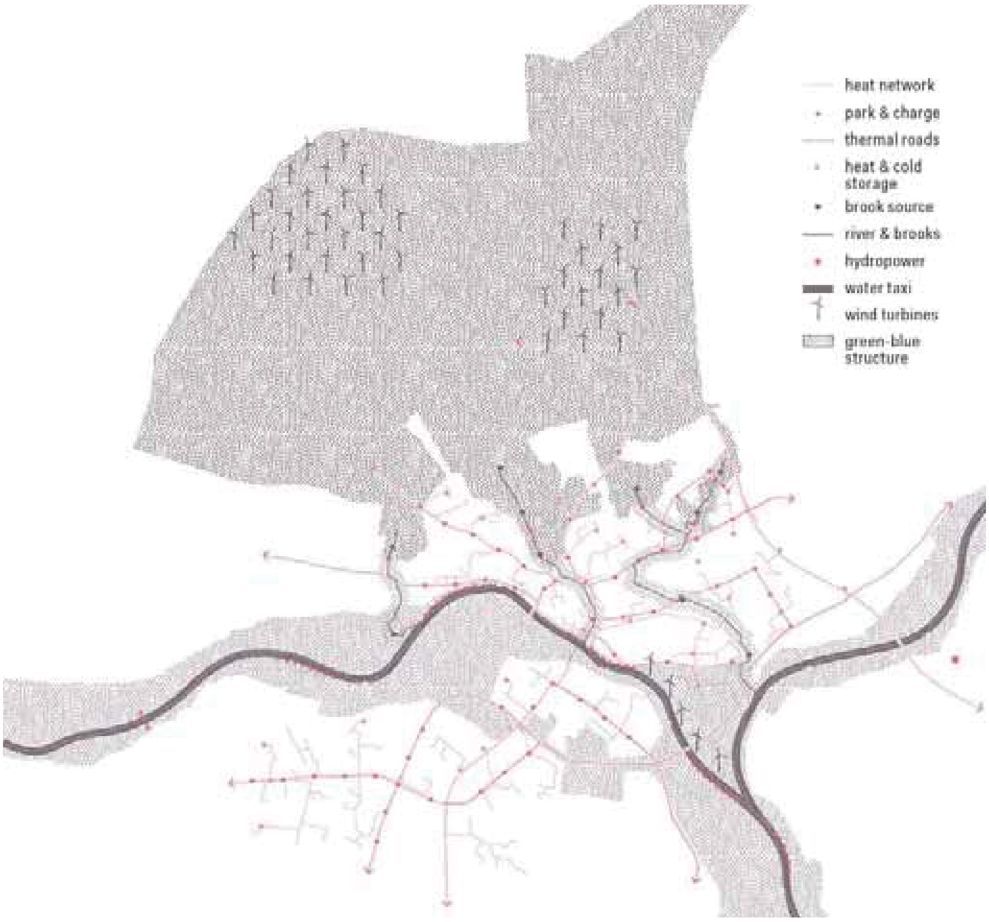


Fig. 12 Landscape and energy: a spatial energy concept (source: Dirk Sijmons, 2014)

Fig. 13 Landscape and energy: a spatial energy concept visualization (source: Dirk Sijmons, 2014)

The scenarios are then broken down into 10-year implementation phases, from 2020 to 2050, highlighting how the transformation of the energy production stock distributed on the territory could be tackled focusing on the development of the most suitable production techniques for the site, but also on the most affordable technologies for the period. It is therefore assumed that technological developments and implementations will make other energy production techniques more advantageous in the future and that they will be integrated into the energy panorama in the decades to come.

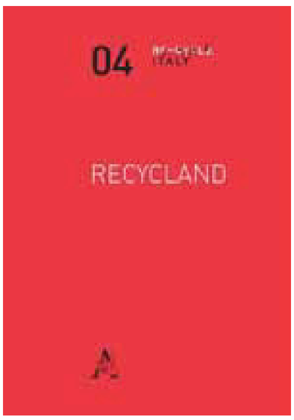
recycle or re-cycle?

Talking about dismissed or ongoing decommissioned industrial and energy infrastructure immediately evokes the use of a very frequent terminology in contemporary sector literature, that is to say *recycle* or *re-cycle*.

The two variations of the same term are used with slight different subtleties, emphasizing different aspects of the debate.

The most classic term *recycle* has a distinctly ecological connotation and mainly concerns strategies and methodologies aimed at recovering useful materials from "waste" in order to reuse rather than dismantling them. In this framework, we can refer to Peter Latz's conversion project of the Duisburg-Nord steel plants (Latz, 2001). Within a much more complex process of "metamorphosis" of an industrial site into a public park (the project will be deepened in Part 3 of our research), uncontaminated concrete materials from demolished buildings are "recycled" as gravel for pedestrian walkways. This type of intervention seems to confirm what McDonough and Braungart argued in their text *Cradle to Cradle* (2002) about interpreting "recycling" as a downcycle process.

The notion of *re-cycle*, on the other hand, focuses on programmatic and spatio-temporal aspects rather than on material ones. Since the productive life cycle has ended, the reflection wonders whether it is possible to imagine starting new life cycles which can then convert the site through a new use for which it was not originally thought.



Within the framework of the Italian Research Program of National Interest (PRIN 2013–2016), the research project *Re-cycle Italy*, led by the IUAV (Istituto Universitario di Architettura di Venezia), represents an exemplary case study which explores the notion of *re-cycle* in this sense. The main objective of this study is to identify those possible strategies for *re-entering* those industrial wastelands into a new productive life cycle. *Re-cycling* implies a shareable ethical responsibility regarding the productive infrastructure that, for decades, brought welfare and know-how to local communities, but now, after its decommissioning, represents an economic, social and environmental problem. In this sense, r*e-cycling* signifies trying to heal territorial scars. Among the proposed points of view, it is interesting to retrace the one proposed by Giovanni Corbellini in some of his essays. He claims the provocative idea of "designing the amnesia" (in the original language "progettare l'amnesia", Corbellini, 2013, p.25), for which *re-cycle* is a design action that has always been present among architectural tools and that the most interesting results are generated by the greatest deviation from the initial situation of the architectural object, reversing original logic and changing the relationship between figure and background. To understand the interest that arises from the tension between two apparently contradictory situations, just think of the transformation of the Teatro di Marcello in Rome into a residential building since the medieval times, or the transformation of Diocletian's Palace into the real historical centre of Split.

re-wiring?

In the framework of the above mentioned *The Petropolis of Tomorrow* research and in particular in an essay published in the review *Volume n.47* in 2016, Bhatia introduces the concept of *re-wiring*, which seems to involve a larger scale than the architectural one proposed by *re-cycle*'s field of action.
Network notion is implicitly included in the term *wiring*, which is normally used to describe the action of connecting electric wires.
For the presented case study lying at the borders among Brazil, Paraguay and Argentina (see Part 2 of the research) Bhatia proposes to rethink the role of oil pipelines that extend over almost 3'500 kilometres. *Hydroscaping* (Bhatia, 2016, p.82) is the systemic strategy proposed for the entire infrastructural ring and it envisages the use of oil pipelines as a *water collection* and *water discharge system* between flooding coastal areas and arid areas in the inland. Resolving a problem due to climate change becomes the possibility of triggering agricultural practices in territories in extreme climatic conditions, thus encouraging the development of local communities hundreds of kilometres away.

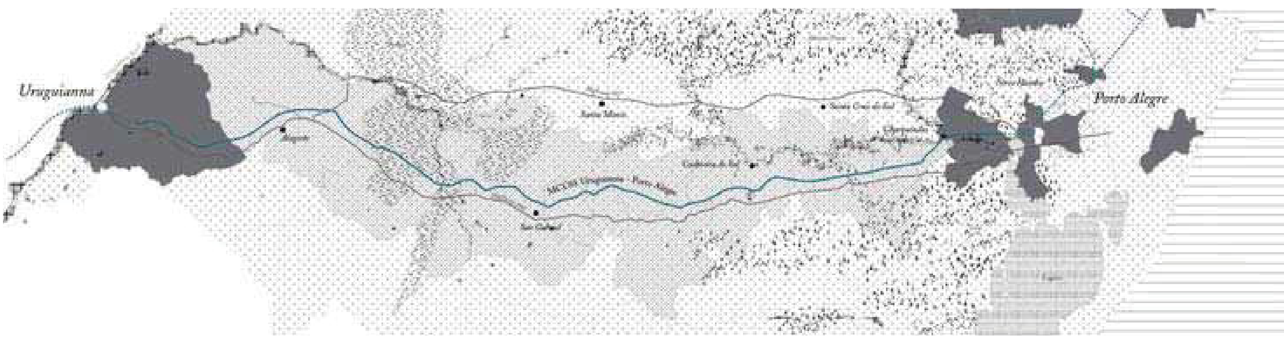


Fig. 14 Re-wiring: oil pipelines ring among Brazil, Paraguay and Argentina (source: Neeraj Bhatia, 2016)

up-sourcing!

Our research would like to contribute to this international debate. In the light of the main theoretical positions seen so far, we would like to consider as starting points some of the previous contributions and try to propose a new narrative for a territorial restructuring which intends to achieve a systemic reconversion of oil meshes. We are interested in:

- *upcycling* notion;
- *re-wiring* scale;
- rejects as *new sources*;
- re-cycle's inversion between *figure and background*.

We therefore believe that **up-sourcing** neologism could describe that new territorial narrative capable of increasing the environmental value of industrial emissions using the existing oil distribution network and allowing to use captured CO_2 as a source for new production processes or services, whether related to energy or not.

Research limitations

geographical limitations

Once the topic of our research has been identified within the debate between *energy* and *landscape* and further narrowed to the relationship between *oil energy infrastructure* and *landscape*, it becomes necessary to define the geographical region where the analysis will be concentrated.
In order to better focus on possible research outcomes, we have chosen to deepen the European Union funding instruments aimed at creating transnational co-operation and promoting territorial stability and competitiveness for the 2014–2020 funding period.
Given the international partnership of the IDAUP doctoral program between the University of Ferrara (Italy) and the Polis University of Tirana (Albania), we thought that it could be interesting to define a geographical research area including both institutions, in order to establish the basis for a possible joint participation in the construction of a European research project proposal.
Thus, we have consulted the Transnational Co-operation Programmes for the South-East Europe and noted that the financing instrument for the 2007–2013 funding period has been separated into three different programmes covering three smaller geographical areas for the 2014–2020 funding period: *Adriatic-Ionian region*, *Danube region* and *Balkan-Mediterranean region*.
The participation as Partner States of both Italy and Albania in the framework of the *Interreg V-B Adrion programme* leads us to accept its geographical limitations as well as those for the macro-territorial research analysis.

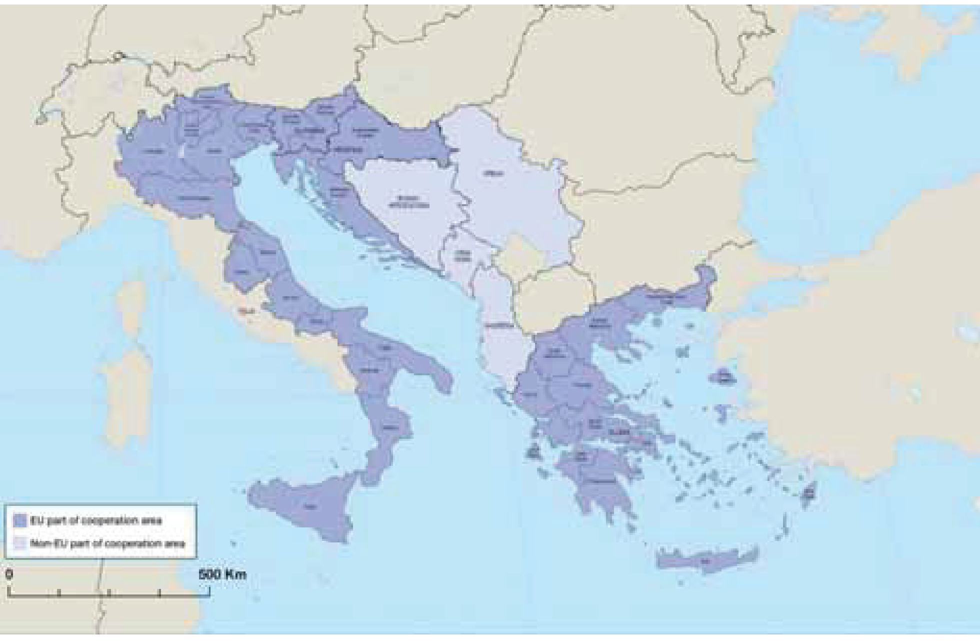


Fig. 15 Adrion region: cooperation area (source: Adrion Interreg Programme)

Adrion region includes eight Partner States, of which four are EU Member States (*Croatia, Greece, Italy and Slovenia*), three are candidate countries (*Albania, Montenegro, Serbia*) and one is a potential candidate country (*Bosnia and Herzegovina*). The geographical area concerned by Adrion programme of each Partner State covers its entire national territory except for Italy, where the programme area covers 12 regions and 2 provinces.
The main objective of Adrion programme is to act as a *policy driver and governance innovator*, fostering the co-operation among highly competitive coastal regions and poorer ones by strengthening a common identity and a territorial cohesion around the Mediterranean Sea and its richness in natural, cultural and human resources.

oil infrastructure limitations

Considering the main subject of our research, namely *oil infrastructure*, it is necessary to make a preliminary distinction, which will be deepened in the following chapters, in order to recognize the main oil industry sectors, that is to say:

- *upstream activities* are related to exploration and extraction of crude oil;
- *midstream activities* involve infrastructure related to transport and distribution of crude oil and its derivatives;
- *downstream activities* refer to all refining processes of crude oil and its transformation into by-products.

As regards upstream activities we need to make a further limitation. In fact, we know that oil can be extracted from the subsoil using various techniques and processes, depending on the geological characteristics of the soil in which oil has been trapped. The most common extraction technique is by drilling in order to reach reservoir rocks below superficial rock layers. Oil reservoirs are unevenly distributed under the earth's surface and may also be situated below the seabed. The distinction between *onshore* and *offshore* extraction plants arises precisely from that differentiation in the location of oil reserves.
The research will only focus on *onshore oil infrastructure* because of its direct relationship with urban developments and mobility infrastructure.
Although offshore infrastructure also has clear relationships with urban developments as previously presented by Bhatia's research *The Petropolis of Tomorrow*, it seems to us that the characteristic isolation from urban contexts and the difficult accessibility generate different kinds of problems if compared with onshore ones and consequently cannot be assimilated within a common research path.

Research objectives

the role of architecture in the energetic transition

Talking about *oil industry* inevitably means talking about *infrastructure*. Resuming what Ruiz (2013) and Bélanger (2017) wrote, during XX century we witnessed a dramatic detachment between engineering and architectural skills, so *infrastructure* was considered to belong to civil engineers, urbanists and policymakers' competences. This irretrievably marked the evolution of a highly technical approach to infrastructure design that profoundly disrupted the landscapes of the second industrial revolution.

Only recently architecture and landscape architecture have understood the importance of reintegrating infrastructure as a multi-scalar design challenge within their tasks. In fact, it is at the infrastructural scale that the great challenges facing contemporary territories and urban regions are dealt with, such as the prevention of environmental disasters related to climate change, or the logistics management for the supply of the dense urban conurbations.

We can try to paraphrase the research question addressed by Ruiz (2013) in his essay published in *The Petropolis of Tomorrow*[1] as follows: can infrastructure be considered a technical object?

Bélanger (2012; 2017) risks a very radical response, supporting the idea of considering "landscape as infrastructure". Both are systems connecting something, both "divide as much as connect" (Bélanger, 2017, p.50). If in their essence the two concepts could be assimilated, probably the author wants to explain that the difference lies in the attitude with which we approach their physical manifestation on the territory: *infrastructure* responds to purely engineering, functional and technical needs, while *landscape* meets a complexity that must accommodate life and for this reason integrates in a systemic way multiple domains and scales. "From engineering to design" (Bélanger, 2017, p.50) represents, from our point of view, a sort of slogan and invitation to integrate the *agency of design*, of which architects and landscape architects are holders, in the infrastructural domain.

The same opinion on the role of the project is shared by the landscape architect Charles Waldheim, who argues that the reintegration of infrastructure domain in the competences of architects and landscape architects would allow to reclaim the social and environmental dimension of the project that has been lost, thus reconnecting the potential of the architectural project to its natural relationship with the history of the territories and the city. (Waldheim, 2011, p. 4–5).

If what mentioned above refers to a general notion of infrastructure, the epochal change in the energy production process evoked by Rifkin (2011) as a fundamental step towards the transition to the third industrial revolution

1 Bhatia, N., Casper, M. (eds.) (2013). *The Petropolis of Tomorrow*. New York: Actar Publishers.

constitutes an immense design opportunity in the field of infrastructure for architecture and landscape architecture that must not be missed. In fact, the transition from a centralized energy production model, which meets energy needs through an intensive production concentrated in few poles scattered throughout the territory, to a territorially distributed and extensive model, where final consumers are also active producers of lower energy quantities that are all distributed on an energy-sharing grid such as the Internet, opens up a field of research that is still unexplored, looking more at the design of *energy landscapes* rather than energy infrastructure. Therefore, it does not only consist of a technocratic issue which involves a mere application of known technologies (wind, photovoltaic, etc.) to the architectural project as if it were a make-up, but it is necessary to change perspective and completely rethink the territory as the main resource for energy production.

Thus, the first objective of the research will be that of demonstrating that, by taking up the radical position of Bélanger, *landscape is also energy infrastructure*, and that architecture and landscape architecture's multi-scalar design approaches could allow to associate those living, ecological and social components with energy infrastructure, or rather with *energy landscapes*.

the role of oil infrastruture in the territorial restructuring

Talking about *oil industry* also means talking about *deep territorial transformations* that have redefined the hierarchies among territorial components (water, nature, industry, inhabited centres), drawing new tangible and intangible cartographies since the end of XIX century. According to Hein (2013, p.437), oil represents a "critical agent in shaping global geographies—urban, rural and maritime—through physical infrastructure at major production sites, along networks of consumption, and through intangible, international flows of the finances, people, and ideas that sustain it".

In view of the above-mentioned energy transition, can we really imagine to forget oil infrastructure and what it brought in terms of territorial networks, hierarchies and transformations, or think of integrating it in a territorial restructuring process, taking advantage of its characteristic ramification? As pointed out by Bhatia (2013), if oil infrastructure has been planned as technical artifacts, highly specific to their intended purposes, how could it be redesigned to be flexible to other uses?

The second proposed aim of the research is to verify if oil infrastructure can have a renewed role, in the sense of *energy landscapes*, in the territorial restructuring process expected for the third industrial revolution.

Methodology

research by design

As it has already been pointed out in the previous introductory pages, oil infrastructure is a very complex subject involving many disciplines and scales. Environmental aspects are inextricably intertwined with technical-functional solutions, made up during political contexts in specific historical moments, so that the sum of all these factors has important repercussions on social aspects. Moreover, each of these variables changes faster than territories can react and try to adapt and integrate them. For this reason, as Roggema argues (2017), "planning the future can no longer be based on the certainty of programmes and conditions". The fluctuating problems' definition of complex situations cannot be addressed with instruments belonging to *the science domain*, which through an analytical approach seeks objective, eternal, replicable truths.

Design, on the contrary, is an exploratory, dynamic and responsive activity to changing situations, which enables creative jumps in the thought-building process allowing to study and evaluate multiple possible futures at the same time, and therefore it can be useful in front of this type of complex situations: "science is analytic, design is constructive" (Gregory, 1966).

As Dewey (1939) stated, analysis is in any case present in the design process and represents an integral part of it, since it marks the transition from a situation of indeterminacy to a situation of determinacy. In fact, reality is shown through the relationships that constitute it, and of which we have had experience. Thus, the project becomes a critical tool that mediates between the relationships experienced, subjects and places.

Viganò (2012) supports a scientific use of *design* as a research tool, arguing that "design practice is a cognitive activity", and for this reason it is "producer of knowledge", as it is a "reconstruction, contextualization and reorganization of the reality" and, quoting Schön (1983), "the epistemological status of the project can serve as a reference for other knowledge and disciplines".

Convinced that design should be explored as a method of inquiry (Roggema, 2017) to open new and unexpected debates, we realize that the methodologyical approach of *research by design* can easily adapt to our exigencies in the study since "it has turned out to be capable of bringing together the worlds of science (facts, forecasts) and politics (involvement, choices) by means of design and imagination" (Sijmons, 2014).

ANALYSIS
agency of mapping

In order to fully understand the impacts and the established hierarchies of oil infrastructure at a territorial scale, *mapping* is the principal tool used during the analysis phase. It consists in the activity of construction of new cartographies through the use of GIS tools, specifically using the free software *QGis 2.10.1 Pisa*.

Metadata containing geographical information and statistical data processed in Excel sheets, all free available on the websites of European, regional, provincial public institutions and of national statistical databases, have been intertwined and superimposed in order to give unexpected interpretations of the territory. As Corner (1999, p.197) asserts:

> "*mapping* is a fantastic cultural project, creating and building the world as much as measuring and describing it. […] As a creative practice, mapping precipitates its most productive effects through a finding that is also a founding; its agency lies in neither reproduction nor imposition but rather in uncovering realities previously unseen or unimagined, even across seemingly exhausted grounds. Thus, mapping unfolds potential: it re-makes territory over and over again, each time with new and diverse consequences".

Mapping agency derives from its double essence: maps are true, measurable, objective, but, at the same time, are abstract, as they are the result of a selection, omission, isolation and codification process (Corner, 1999, p.199).

ANALYSIS
taxonomy

Given the several infrastructure typologies related to the fossil-fuel industry and also the geographical differences among Adrion territories, the research will produce a *taxonomy* of the most important territorial networks established by fossil-fuel infrastructure (oil, gas and coal). The existing types of upstream, midstream and downstream infrastructure on the Adrion territories will be described through two different approaches:

- a systemic description of territorial networks and of their individual components through the use of mapping;
- a description of the most relevant nodes of the networks, using zenithal images, quantitative and qualitative information related to the type and capacity of the energy production.

The taxonomy of fossil fuel infrastructure networks will therefore allow to classify the principal functional dependencies between certain sites, as well as to identify, by superimposing geographical information related to natural environments, the types of risky intersections between fossil-fuel industry and protected areas.

ANALYSIS
comparative analysis

Comparative analysis is a crucial part of the research. Two territorial models, representative of the infrastructural development of the two experienced industrial revolutions, will be chosen in order to understand which kinds of relationships and hierarchies have been established among infrastructure, industrial settlements and inhabited centres in the two different industrial eras.
Our territorial case studies will be compared through the use of thematic cartographies, expressly produced using GIS tools, and through the reconstruction of the current research framework resulting from the consultation of the main specialized literature of recent decades about their territorial development.
Since contemporary territories are still the physical expression of infrastructure policies belonging to the two industrial revolutions, the comparative analysis' objective consists in identifying which one of the territorial hierarchies can be unhardened and redesigned in the light of the energy transition to the third industrial revolution.

DESIGN
scenarios construction

Scenarios are a narrative form of spatial futures which are the result of an experimentation process directly applied on case studies, based on the use of reasoning and design tools, that must work within a previously defined set of limitations and assumptions (Viganò, 2012 and Sijmons, 2014).
The flexibility of the scenarios construction tool lies in the possibility of redefining the objectives, programmes and stakeholders in relation to any change in the basic assumptions, thus enabling a targeted and simultaneous reasoning on multiple aspects and on the effects of each one.
Scenarios contain, manipulate and create concepts. They discern the peculiarities of situations, and speculate on their possibilities with a disruptive potential.
That is why scenarios are used to open up debates and not to define a unique future development in a closed way. As Viganò (2012) reminds us, it is very often the *unacceptable scenario* that has the most constructive role, as it has the function of showing a future that is absolutely not desired.
As scenarios are multi-scalar, through the reading of some statistical maps we will try to outline a general macro-territorial development context towards the notion of *energy landscapes*, within which we will try to test two different scenarios on a specific oil mesh.

ASSESSMENT
multi criteria decision-making

In order to have an objective evaluation of their impacts, each scenario must be measured through common assessment criteria. *Multi criteria decision-making* is a tool which enables decision makers to first choose the criteria on which to define the general objectives of a territorial development rather than the development itself.

Expected results

Expected results can be grouped according to their scale of influence:

Adrion scale

- recognition of the principal *Adrion oil meshes* in order to identify their range of action and functional dependencies;
- identification of the main stakeholders to be involved in future research or projects, such as regions, provinces, municipalities and operating multinational energy companies;
- localization of those endangered areas of conflicts between protected natural areas and oil infrastructure network;

oil mesh scale

- definition of the role of oil meshes in the territorial restructuring perspective of the third industrial revolution as part of *green infrastructure*;
- affirmation of the potential of a trans-regional systemic programming of oil meshes based on their functional connections and dependencies;
- proposals for a trans-regional programming tool for oil meshes reconversion able to manage a coordinated territorial development;

site scale

- outlining the limitations and assumptions for scenarios construction;
- definition of some design tools for the representation of a cyclical space-time articulation of the narrative of scenarios;
- selection of multiple criteria for the assessment of scenarios.

Stakeholders

European Union Framework Programmes

The subject of the research has been conceived and shaped looking at the fulfilment of *Europe 2020 strategy*[1] and focusing on the principal topics of the European Commission funding programmes for the period 2014–2020.
Three are the principal political priorities outlined for the work programmes: s*mart growth, sustainable growth* and *inclusive growth*.
Research proposals are asked to focus on giving innovative responses in employment, education, research and innovation, social inclusion, poverty reduction, energy efficiency and climate change domains.

direct and indirect funding programmes

EU financial instruments are manifold and can principally be divided into two macro-categories: *direct* and *indirect funding programmes*.
Direct funding programmes are directly managed by the European Commission through Directorate General or delegated agencies which receive and approve project proposals. No intermediary institution is between the funding provider and the beneficiary.
On the contrary, *indirect funding programmes*, also known as *structural funds*, share the management of the funds between the Member States and the European Commission. Thus, national, regional or local authorities handle the direct relationship with the proposers and are called to organize the action plans and manage the financial resources.

direct funding programme: Horizon 2020

Horizon 2020[2] is the vastest EU Framework Programme for Research and Innovation, disposing of nearly 80 billion Euros over 7 years (2014–2020). It is organized in multiannual work programmes according to main research axes.
The current closing Work Programmes 2016–2017 identify some research pillars facing to contemporary European challenges. The *societal challenges* pillar results to be the one that is more related to environmental and urban matters.
It is interesting to notice that some of the H2020 calls for projects would have been suitable opportunities to which apply innovative proposals built around the topics of the present research, so confirming the actuality and the interest that the European Union targets towards these matters.
As examples, in the following sheets we have briefly identified some *work programmes* and *calls for projects* emphasizing how the theoretical apparatus of the research could have contributed in the international debate.

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1 "Europe 2020 is the European Union's ten-year jobs and growth strategy. It was launched in 2010 to create the conditions for smart, sustainable and inclusive growth. Five headline targets have been agreed for the EU to achieve by the end of 2020. These cover employment; research and development; climate/energy; education; social inclusion and poverty reduction" (see ec. europa. eu/europa2020).
2 "Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness." (see ec.europa.eu/programmes/horizon2020/en/what-horizon-2020)

direct funding programme: COST

Another interesting instrument, belonging to Horizon 2020 framework programme, is *COST*[3]*—European Cooperation in Science and Technology*. COST funding programme supports the transnational co-operation among researchers across Europe, to develop ideas through a fully open "bottom-up" approach across all research fields. The aim of COST is to set up transnational networks around specific topics, so offering the researchers the possibility to establish multidisciplinary co-operation and to improve ideas by sharing them within the network. COST actions are funded for a period of 4 years and cover networking expenses (meetings, conferences, scientific exchanges, publications), but don't support the research itself. The collection of COST proposals is organized through a continuous Open Call.

direct funding programme: LIFE

LIFE[4] is the European Union's financial instrument supporting environmental, biodiversity, nature conservation and climate actions. It is subdivided in four principal themes: *nature and biodiversity*, *environment*, *climate action*, *info and governance*. Each of these axes is organized around some fields of interest for which periodical call for proposals is held, searching for innovative projects which could contribute to the implementation, updating and development of EU environmental and climate policy and legislation. The creation of *green infrastructure*, *life-cycle assessment of dismissed industrial areas*, *reduction of the environmental impact of industrial production*, *landscape protection*, *land-use development* and *innovative spatial planning approaches* could represent just some of the possible axes concerning oil infrastructure's rehabilitation on which it would be plausible to set the research main guidelines responding to LIFE programme's expectations.

indirect funding programme: ERDF

European Regional Development Fund (ERDF) is a financial instrument for the implementation of regional policies and for the reduction of disparities among the European regions. ERDF objectives focus on *convergence* (modernization and diversification of economic structures, creation of sustainable jobs, stimulation of economic growth, with a particular attention to urban, remote, sparsely populated regions), *regional competitiveness and employment* (innovation and knowledge economy, environment and risk prevention, access to transport and telecommunications) and *territorial co-operation* (cross-border economic, social and environmental activities, transnational co-operation, inter-regional co-operation,

3 "COST is an EU-funded programme that enables researchers to set up their interdisciplinary research networks in Europe and beyond. We provide funds for organizing conferences, meetings, training schools, short scientific exchanges or other networking activities in a wide range of scientific topics. By creating open spaces where people and ideas can grow, we unlock the full potential of science." (see.www.cost.eu)

4 "LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU. Since 1992, LIFE has co-financed some 4306 projects. For the 2014–2020 funding period, LIFE will contribute approximately €3.4 billion to the protection of the environment and climate." (see http://ec.europa.eu/environment/life/)

including networking and exchange of experiences between regional and local authorities). The domains of interest are transversal and include: l*ocal development, energy, environment, industry, innovation.*
Funds are principally handled by the Member States through regional and local authorities, with the supervision and the control of the European Commission. Due to the specific attention to territorial issues, local and regional authorities are the principal stakeholders and proposers, in partnership with research centres and, in some cases, with SME and private stakeholders.

indirect funding programme: INTERREG

The *European Territorial Cooperation* (*Interreg*) supports cohesion policies in order to implement joint actions at different levels to encourage a harmonious development of European regions. *Interreg* is organized in three different sub-programmes:

- *Interreg A:* for cross-border cooperation
- *Interreg B: f*or transnational cooperation
- *Interreg C:* for interregional cooperation

The 2014–2020 period for Interreg V programme focuses on 11 investment priorities which have to contribute to the achievement of the *Europe 2020 strategy for smart, sustainable and inclusive growth*, such as low-carbon economy, environment and resource efficiency, sustainable transport, social inclusion, employment and mobility.
The inter-regional and transnational distribution of oil infrastructure on the European territories matches with the objectives identified by Interreg programmes and could constitute the ideal leitmotif around which building a territorial co-operation research proposal.

INTERREG A

Among Interreg A, the proximity of regions, the physical oil infrastructure network or the sharing of similar experiences related to oil sites could allow to accede to some bilateral programmes, such as Italy-France, Italy-Greece, Italy-Croatia and Italy-Switzerland programmes.

INTERREG B

Wider areas and territorial networks are taken into consideration in the Interreg B programmes, among which we want to mention the Interreg Adriatic-Ionian region (Adrion), the Interreg Central Europe region and the Interreg MED (Mediterranean) regions. Their recent calls for projects focused on some priority axis, such as promoting innovation capacities to develop smart and sustainable growth, fostering low carbon strategies and energy efficiency in urban and remote areas, protecting and promoting natural and cultural resources and promoting sustainable and low-carbon transport systems. Each of these axes

could represent a plausible research issue.
In particular, due to the territorial characteristics of the Adriatic-Ionian region, the research analyses oil infrastructure settled on Western and Eastern coasts of the Adrion region.

INTERREG C: URBACT and ESPON

Interreg C includes a general interregional co-operation programme (Interreg Europe) and 3 networking programmes, among which:

- *Urbact*: the aim of this tool is to promote sustainable urban development through the exchange of experience and through the dissemination of knowledge among European cities;
- *Espon* (European Spatial Planning Observation Network): its aim is to create a European network of applied research which observes the EU's territorial development.

private stakeholders

Oil infrastructure and energy production sites mostly belong to private stakeholders. In Italy we can mention, only as examples, Eni, Enel, Terna, Lukoil, Esso, Ies and Total-Fina. Due to the downstream sector crisis that we are witnessing on western territories of Adrion region, we can imagine that dismissed oil industry sites could only increase in next years, so leaving polluted sites with high cleaning-up costs for owners or local authorities.
Private stakeholders are more and more interested in preventively investing in applied research and consultancies led by Universities and research centres for the elaboration of *feasibility studies* for the reconversion of their dismissed or dismissing productive sites.
Another interesting opportunity is represented by the *Futur-E programme,* launched by Enel spa, for the reconversion of some of their dismissed thermal power plants. In the light of the shift of the energy production model from a centralized structure, managed by multinational companies, to a territorial distributed one, where every consumer is also an active mini-producer who shares energy with other users, Enel is asking to explore, through open calls for projects, innovative and alternative business models for the reconversion of thermal power plants in "eclectic plants" which can combine cultural and socio-ecological realms within a renovated programme.

Pillar

Societal Challenges

Work Programme

Climate action, environment, resource efficiency and raw materials

Call

Greening the economy

Topics

SC5-21-2017: Cultural heritage as a driver for sustainable growth

Specific challenge

European cities and rural areas are unique cultural landscapes full of character at the core of Europe's identity. They are examples of our living heritage which is continually evolving and being added to. However some of them are facing economic, social and environmental problems, resulting in unemployment, disengagement, depopulation, marginalization or loss of cultural and biological diversity. These challenges create demand for testing and experimenting with innovative pathways for regeneration. Cultural heritage (both tangible and intangible) can be used as a driver for the sustainable growth of urban and rural areas, as a factor of production and competitiveness and a means for introducing socially and environmentally innovative solutions. The overall challenge is to go far beyond simple conservation, restoration, physical rehabilitation or repurposing of a site and to demonstrate heritage potential as a powerful economic, social and environmental catalyst for regeneration, sustainable development, economic growth and improvement of people's well-being and living environments.

Relevance with the research

The original productive nature of oil infrastructure does not have to be forgotten in its reconversion process. Even if in a very impacting and oil-centred way, rural and urban areas ran around this energetic productive model for almost a century and they are the morphological result of long processes of territorial transformations. In the light of the third industrial revolution, the intangible cultural heritage of energy production sites could be coupled with new socio-ecological values, looking at innovative ways to produce renewable energies and integrating a new kind of urbanity. This territorial strategic vision could represent a real opportunity for implementing a sustainable growth in uncompetitive regions based on the reconversion of existing oil infrastructure towards the green economy's horizons.

Pillar

Societal Challenges

Work Programme

Europe in a changing world – inclusive, innovative and reflective societies

Call

Understanding Europe – promoting the European public and cultural space

Topics

SC6-CULT-COOP-07-2017: Cultural heritage of European coastal and maritime regions

Specific challenge

European coastal and maritime regions have—over several millennia—developed a rich, multi-layered and varied cultural heritage. At the crossroads of different types of contacts of European peoples with each other and with other regions of the world (from commerce to conquest, from cultural exchange to mass tourism) they represent an extremely rich tangible heritage (coastal towns and villages, submerged landscapes and underwater artefacts, harbours, dams, light houses, arsenals, buildings of the fishing and marine industry, boat builders, etc.). As a result of a combination of natural landscapes and human ingeniousness, including unique types of transcultural communication and ethnic diversity, specific coastal cultural landscapes emerged on the shores and sea beds of Europe.

Relevance with the research

Coastal territories have always been evolving lands, due to natural and human processes of territorial transformation. Industrialization found in coastal lands a suitable environment to set up its infrastructure, so carrying new productive patterns and becoming one of the most important elements for the organization of contemporary landscapes. From the beginning of XX century, oil industry contributed in a massive way to these territorial transformations. Thanks to their tangible and intangible heritage, we can consider oil infrastructure being descriptive of a particular socio-economic context and of a diffused cultural know-how within local populations, as a relevant component of our industrial cultural heritage. In this sense, oil infrastructure represents a "palimpsest" (the result of natural and anthropic processes of stratification, Corboz, 1983) and a "milieu" (carrier of specific socio-cultural values, Governa, 1998) at the same time, and we can think to propose these coastal territories as testing grounds to set up local competitive development strategies rooted in their cultural tangible and intangible heritage.

Scalability of the research subject

Clearly, the scope of the research is not limited to the Adrion region. Oil infrastructure is distributed on all continents (and even on the oceans), with higher or lower concentrations of downstream or upstream sites which are generally linked by pipelines that can reach thousands of kilometres. If we broaden the boundaries of the analysis to Central Europe and take a look at the (not exhaustive) map published in the *Gas and Oil pipelines in Europe* document by the Directorate-General for Internal Policies[1] in 2009, we can have an overview of the dense oil infrastructure network that crosses entire countries in the heart of Europe. And then fossil-fuel infrastructure continues in the neighbouring countries, to reach the major distribution axes that come from Russia.

The Druzhba pipeline, for example, is the longest in the world (4'000 km) and, starting from Eastern Russia, crosses Ukraine, Belarus, Poland, Hungary, Slovakia, Czech Republic and Germany.

This example demonstrates the infrastructural effort that has been made in the past and, at the same time, it shows the real potential that can derive from rethinking its socio-ecological role being an existing and widespread network, once the energetic transition makes oil obsolete.

We can imagine that the methodology proposed by the research could be applied to other trans-regional or even transnational oil networks.

The possibilities that are related to the application of the research methodology range from the implementation of a local development processes up to a macro-territorial vision of the role of European oil infrastructure network in view of the third industrial revolution. The scales of intervention, therefore, are intertwined, coexist and rear feed each other.

1 See http://www.europarl.europa.eu/RegData/etudes/note/join/2009/416239/IPOL-ITRE_NT (2009)416239_EN.pdf, p.35

Fig. 16 Gas and oil pipelines in Europe (source: Directorate-General for Internal Policies, 2009)

PART II

Oil infrastructure

The visible and invisible structures of oil industry

Oil wells, pipelines, refineries, petrochemical sites and thermoelectric power plants have established a contradictory relationship with the territories which host them: if, on the one hand, they represented for decades a working opportunity for local communities, on the other they exploited and consumed immense amounts of territorial resources, causing serious environmental damages. In view of the energetic transition towards renewable energies foreshadowed by Rifkin's third industrial revolution (2011), we have to question about the role which existing oil infrastructure could play in a territorial restructuring perspective which envisages unhinging the territorial hierarchies and dependencies created by the technical functioning of second industrial revolution's fossil fuel infrastructure. Thus, it will be necessary to disassemble the oil industry's system in its visible and invisible structures so as to understand how oil infrastructure shaped second industrial revolution's landscapes.

nanostructure

The vast number of industrial applications of crude oil depends on the innumerable chemical-physical reactions that could occur. The latin word *petroleum*[1] comes from *petrae oleum*, that is to say *rock oil*, and it intrinsically refers to its organic nature, the result of a mixture of different weight and consistency hydrocarbons. The elemental crude oil composition is within the following limits: carbon 79-89%, hydrogen 9,5-15%, nitrogen 0,02-2%, oxygen 0,1-7%, sulfur 0,01-6% and paraffinic, naphtenic and aromatic hydrocarbons. It results from the transformation by anaerobic bacteria of animal and vegetable organic

1 see http://www.treccani.it/vocabolario/petrolio/

substances contained in large *sapropel*[2] masses formed on the bottom of low seas or lagoons. Crude oil is recognizable due to its viscous consistency, yellowish to brownish-black, with a characteristic odor and a blue-green fluorescence. Crude oil processing to obtain a vast product range is generally called *refining*. In order to obtain several types of by-products, refineries perform two main operations on crude oil: first, a primary fractionation (*topping*) is necessary to separate gaseous substances from liquid ones and to get intermediate products, consisting of fractions having different boiling range; then, specific processes (i.e. *cracking*, *reforming*) are applied to each type of fraction, mixing additives if necessary, to obtain final by-products to be sold. Just as an example, *benzene* (C_6H_6) is a monocyclical aromatic hydrocarbon, composed by six carbon atoms joined together in a ring with a hydrogen atom bonded to each carbon, which is normally contained in crude oil. Once isolated, it is a suitable component often used in petrochemical activities because, by replacing one or more hydrogens, a large number of benzene derivatives can be created, such as *fluorobenzene*, *toluene,* which are used in several industrial domains (pesticides, paints, etc.).
The primordial relationship between *oil infrastructure* and *landscape* must be sought in the infinitesimal scale of molecular structures of oil components.

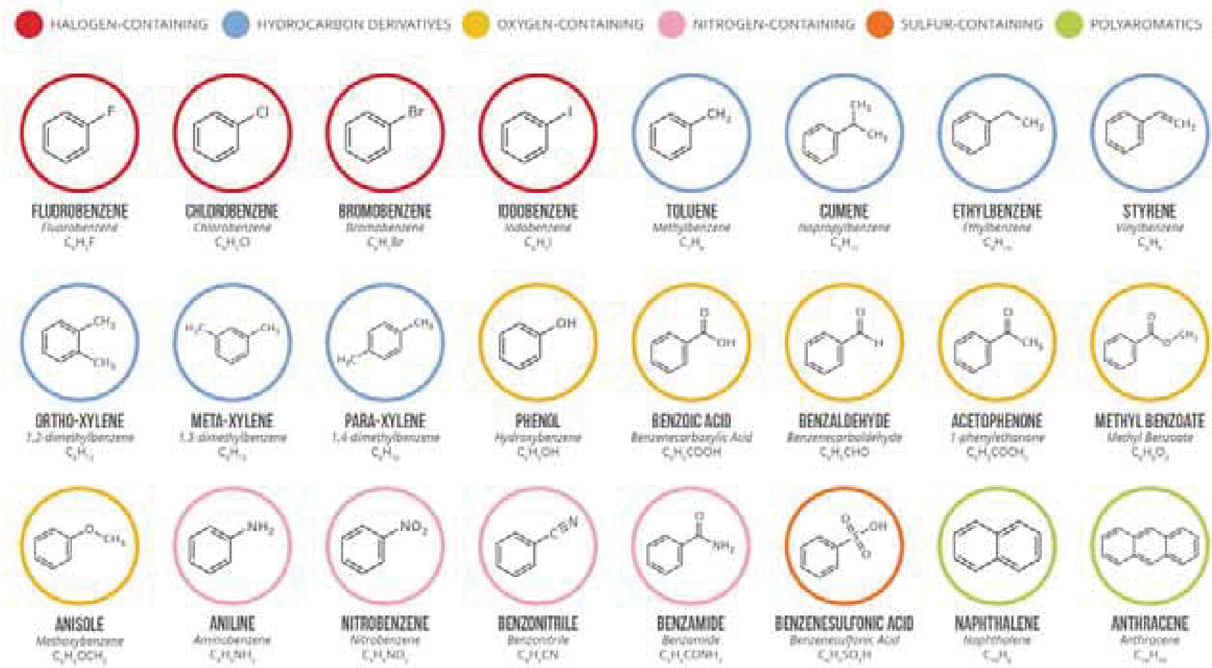


Fig. 17 Benzene derivatives in organic chemistry (source: compoundchem.com)

2 *Sapropel* is a term used in marine geology to describe dark-coloured sediments that are rich in organic matter.

Energetic infrastructure and industrial revolutions

urbanstructure

During the last two centuries, the greater or lesser availability in the subsoil of fossil fuels completely redefined the geo-political equilibrium among European and non-European countries. From the beginning of the industrialization era until today the extraction of carbon-fossil resources has required the investment of huge amounts of funds, because of the deployment of a widespread infrastructural network. The tight bond among *energy sources*, *energetic infrastructures* and *mobility infrastructures* generates very different territorial transformations and urban developments depending on whether it belongs to the first or second industrial revolution.

Quoting the international renowned American economist Jeremy Rifkin (2011), the two experienced industrial revolutions differ as follows:

- the *first industrial revolution* has been entirely dominated by the transformation of thermal energy into mechanical energy through coal-steamed powered engines. The abundance in coal of some European regions, such as the Ruhr region in Germany, the Wallonia region in Belgium and in the North West in England, has been the principal carrier of the first developing industrial regions. The territorial dependency to the geographical location of coal mines, generally away from urban centers, gave a remarkable boost to the implementation of a dense railway network. Thus, heavy industrial activities and workers' dwellings grew in the suburbs connected to major urban centers by a dense railway network. At the beginning of the XX century the *Garden City*[3] proposed by Ebenezer Howard (1898) became the alternative urban development model which better responded to the overpopulation of the major city centers and to the consequent depopulation of the countryside. With his Garden city model E. Howard proposed an ideal agrarian lifestyle for workers employed in industries, capable of distributing the population in the countryside in an organized and balanced manner avoiding urban slums, in harmony with the nature and connected to urban centers by railways, so allowing a more rational use of the territory;
- at the end of the XIX century coal was starting to be substituted by crude oil as principal energy source, so officially defining the transition from the first to the *second industrial revolution*. Nevertheless, crude oil was not so spread as coal in the subsoil of the industrialized European territories. Thus, at the beginning of the XX century, most of the European countries adopted colonialist political strategies against North African and Middle-

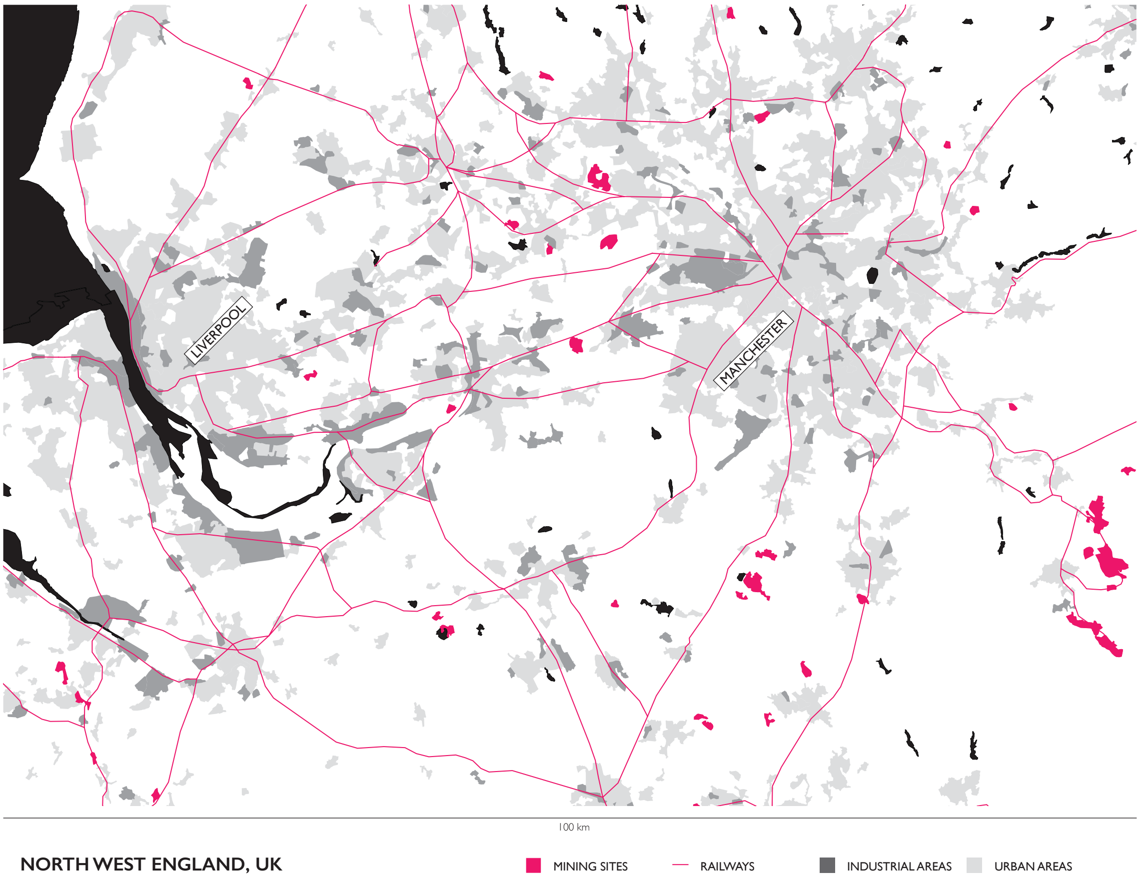
3 In *To-morrow: A Peaceful Path to Real Reform* (1898), E. Howard asserts that Garden City model is constituted by a central green area around which low-density residential areas would be developed, served by wide avenues and a railway infrastructure surrounding the agglomeration.

Eastern countries so as to own and directly manage crude oil exploration and extraction. In the meanwhile, the European countries started the long process of infrastructuring their native coasts with extensive industrial harbours to store and refine the huge quantities of crude oil coming by oil-tankers from the colonies. During the first half of the XX century, the Western mediterranean countries, and in particular Italy, adopted some economic development strategies apt to promote industrialization processes in underdeveloped and almost agricultural regions, in order to specialize their know-how in refining and petrochemical sectors[4]. The results are still under the eyes of everyone and are representative of the violent relationship between *energy* and *landscape* during the second industrial revolution: several refineries, petrochemical sites and oil-based power plants appeared in proximity with new industrial harbors along the European Mediterranean coasts, generally in correspondence of fragile ecological environments. If downstream oil sector brought on the Western Mediterranean coasts harbours and huge industrial districts, midstream activities implemented energetic and mobility infrastructure in a wider scale. In fact, lots of kilometers of underground pipelines and roads have been realized to provide the vastest territory with petroleum by-products. After World War II, the reconstruction period was characterized by a diffuse increasing economic well-being which made automotive industry accessible to a wide spectrum of users, so boosting the spread of mobility infrastructures such as *highways*. The second industrial revolution's urban planning models lie on Keynesian consumerism principles[5], envisaging the settlement of low-dense, monofunctional and car-dependent residential neighborhoods far away from dense city cores, in a process called *suburbanization*.

In order to confirm the evocated diversity of the two infrastructural developments caused by different energy sources, it is interesting to compare some GIS cartographical excerpts of some European case studies which have been deeply shaped by first or second industrial revolutions' dynamics and focus on railways

4 We are referring, for example, to the main legislative measures related to the creation of the industrial harbour and refining activities in Marghera (Legislative Decree n.1191/1917, integrated in R.D.L. n.1909/1926 converted into law n.1074/1927 and R.D. n.2193/1926, converted into law n.1095/1927. These are followed by further conventions and decrees mainly for the extension of the concession deadline until 1944), the petrochemical industrial area in Ferrara (R.D.L. n.2455/1936, converted into the law 17.06.1937 and integrated into the law n.847/1942.) and the petrochemical and refining activities in Siracusa (Legislative Decree n. 416/1944 for the establishment of an industrial Credit Section for medium-long term financing for the settlement of industrial plants).

5 In his *Geografia. Un'introduzione ai modelli del mondo* (2003), Franco Farinelli describes the relationship between economic models and urban forms. American suburbanization process is the result of the application of consumerist Keynesian economic principles in urban planning strategies during the '60s: the choice to settle new mono functional neighbourhoods far away from public equipment and urban centres will make necessary the property of a car to move, which in turn will need fuel, tires, roads and maintenance, so fuelling the welfare of the country's economy thanks to the beneficial effects on several industrial sectors.



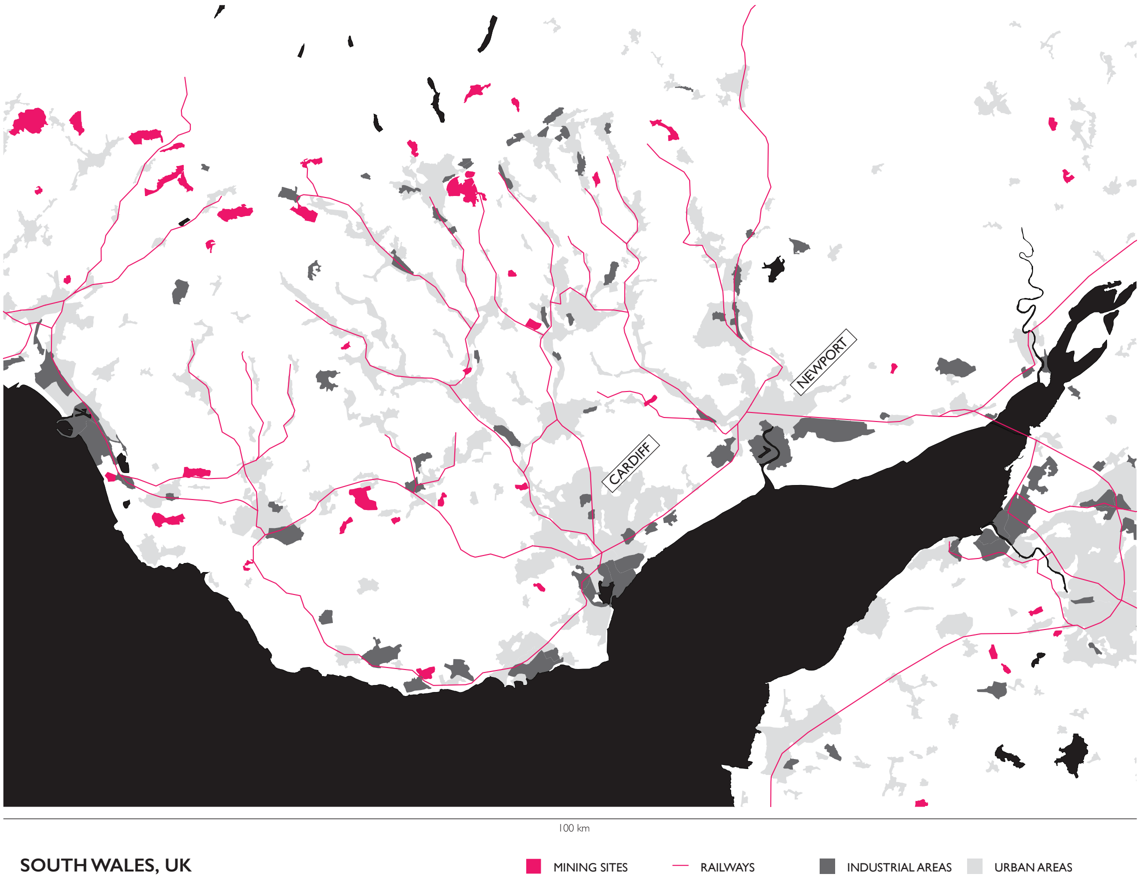
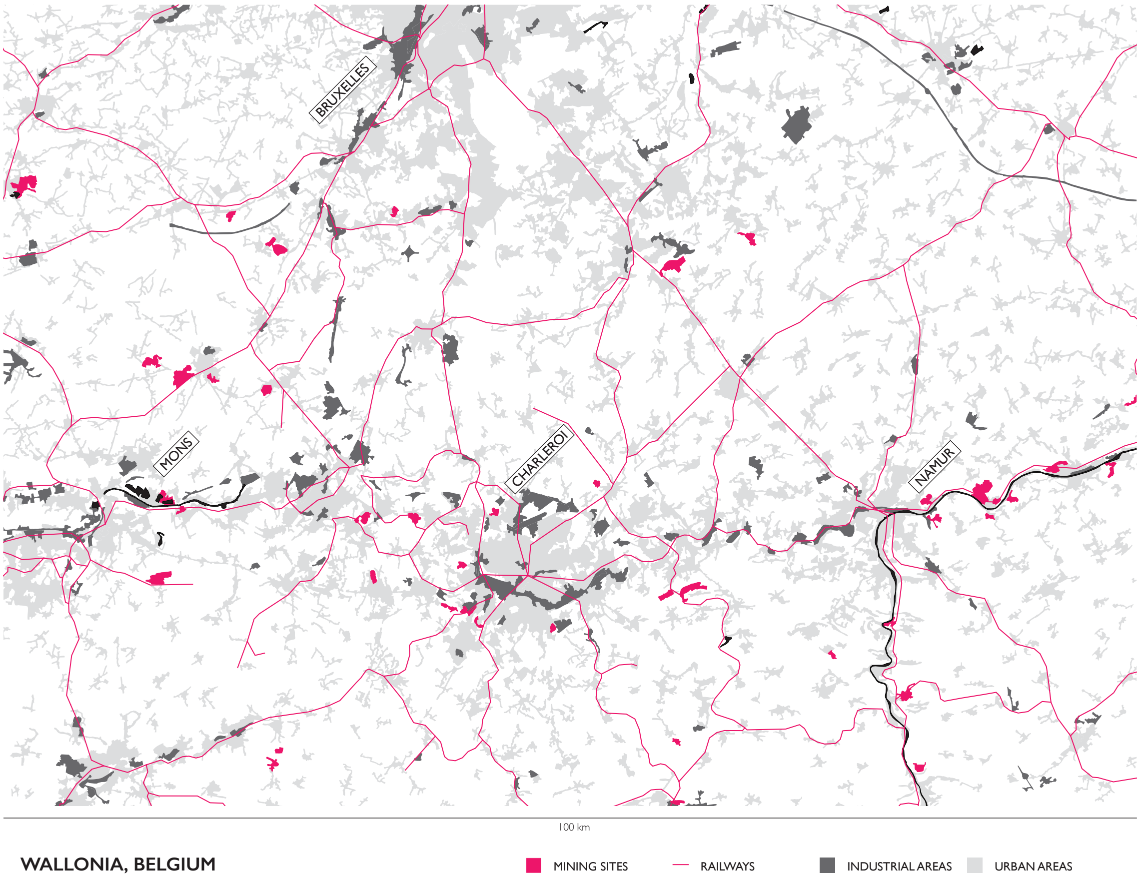


Fig. 18-19 Infrastructural development of the first industrial revolution (elaborated by the author, source: Corine Land Cover)



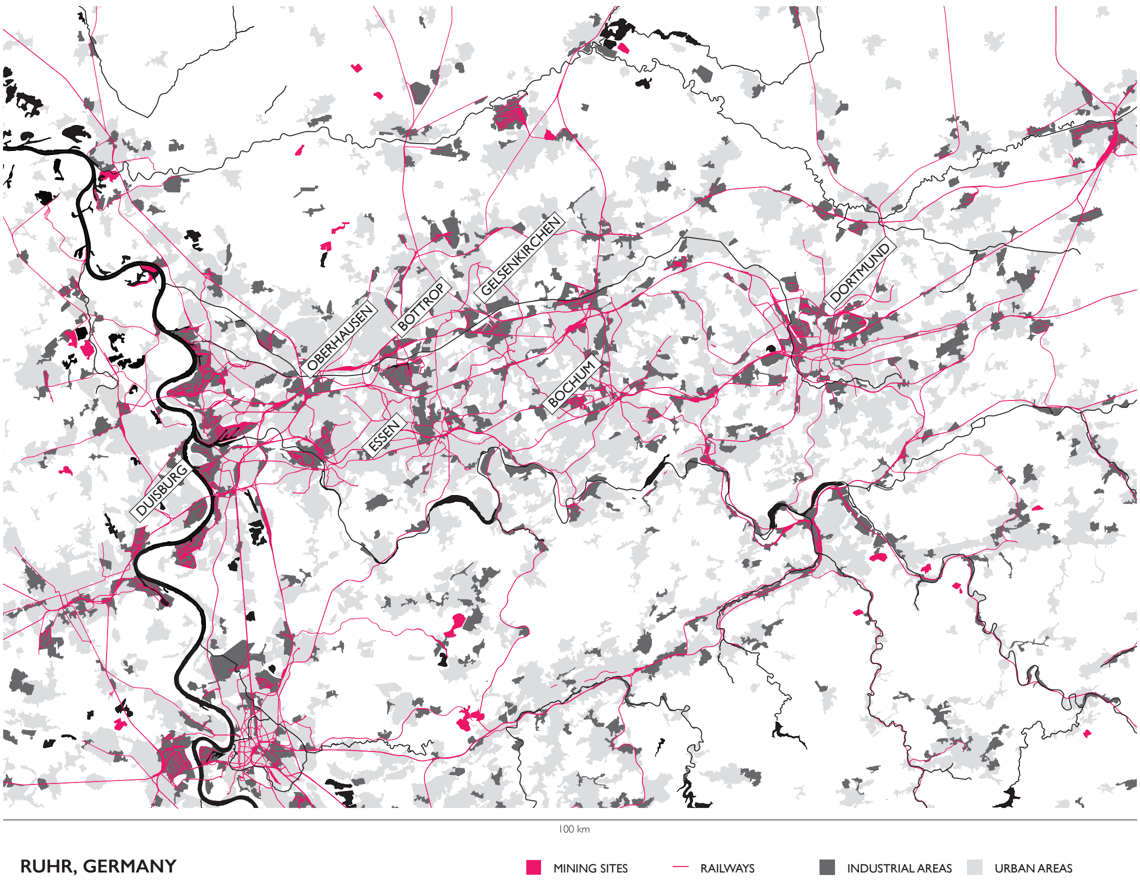
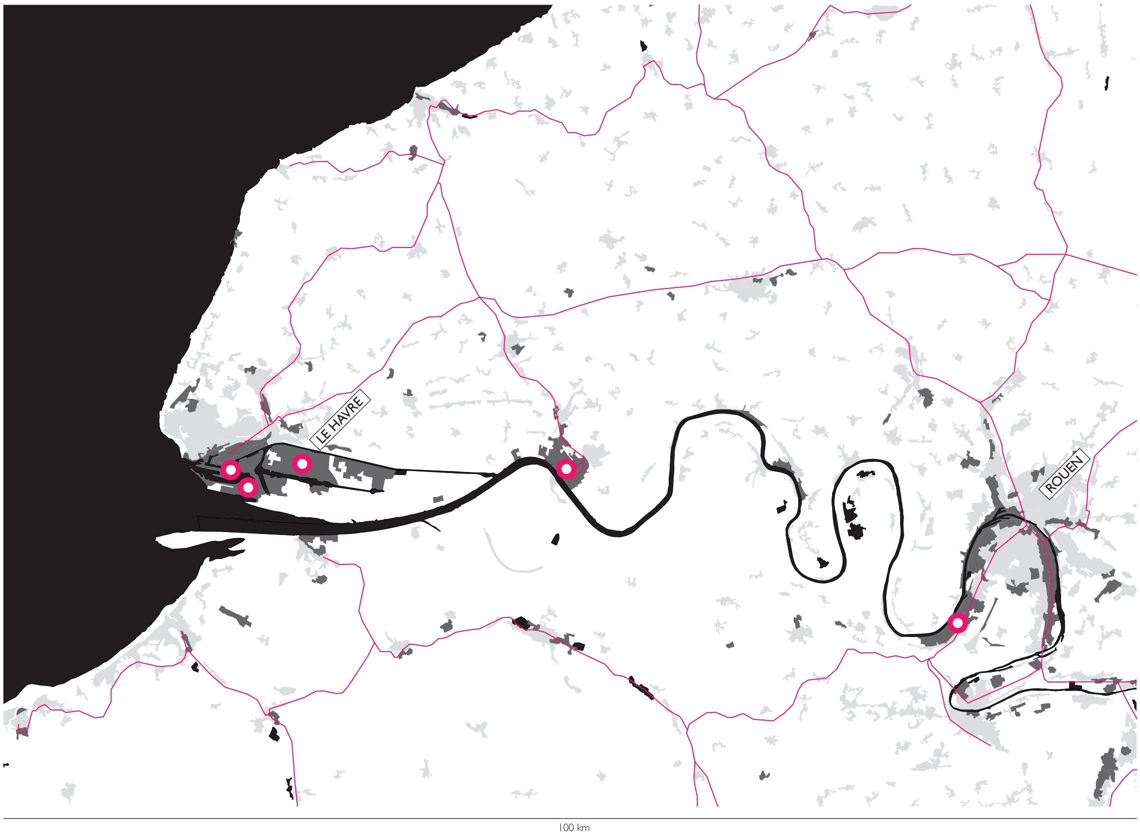
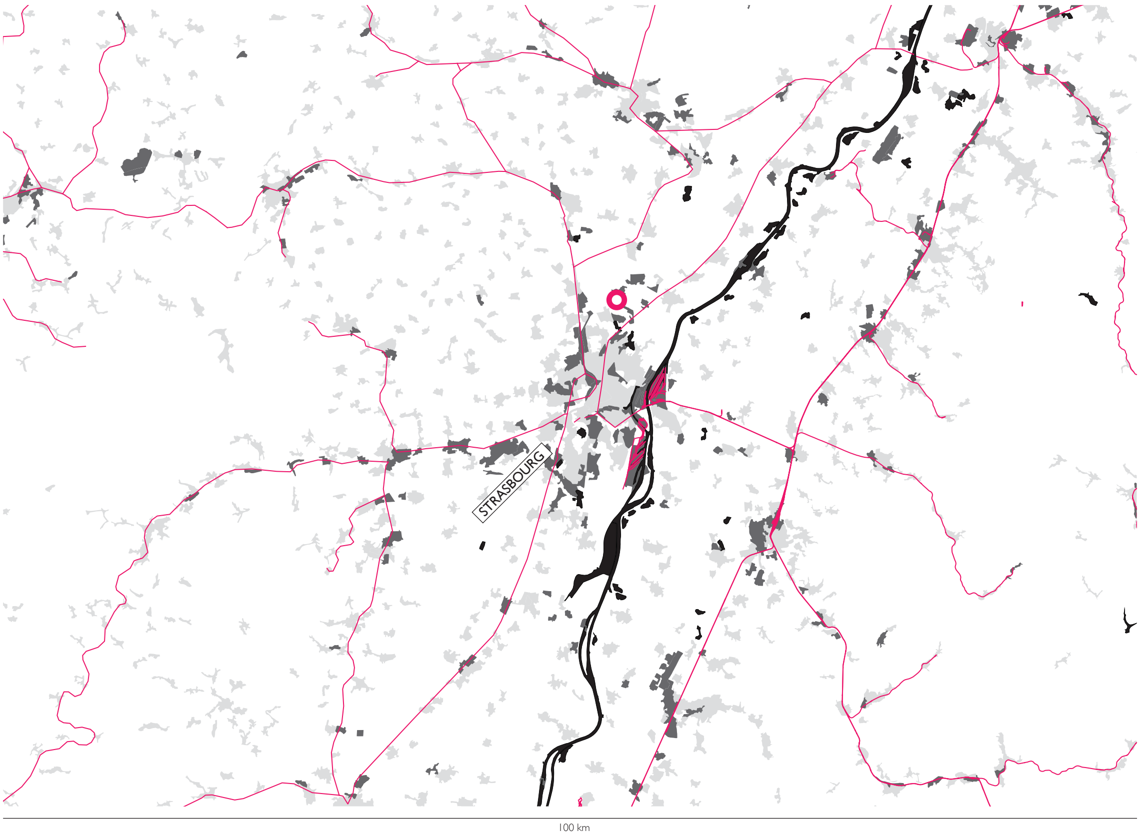


Fig. 20-21 Infrastructural development of the first industrial revolution (elaborated by the author, source: Corine Land Cover)



LE HAVRE, FRANCE

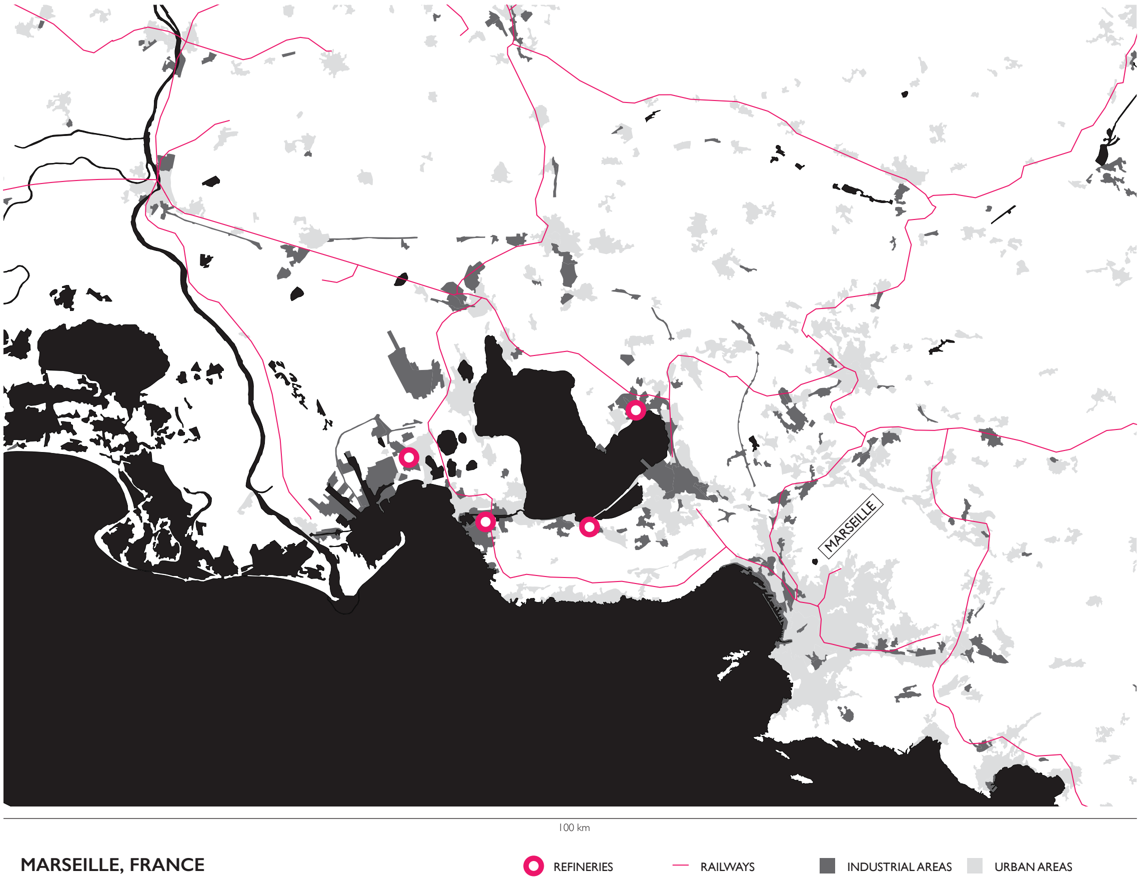
REFINERIES — RAILWAYS — INDUSTRIAL AREAS — URBAN AREAS



STRASBOURG, FRANCE

REFINERIES — RAILWAYS — INDUSTRIAL AREAS — URBAN AREAS

Fig. 22-23 Infrastructural development of the second industrial revolution (elaborated by the author, source: Corine Land Cover)



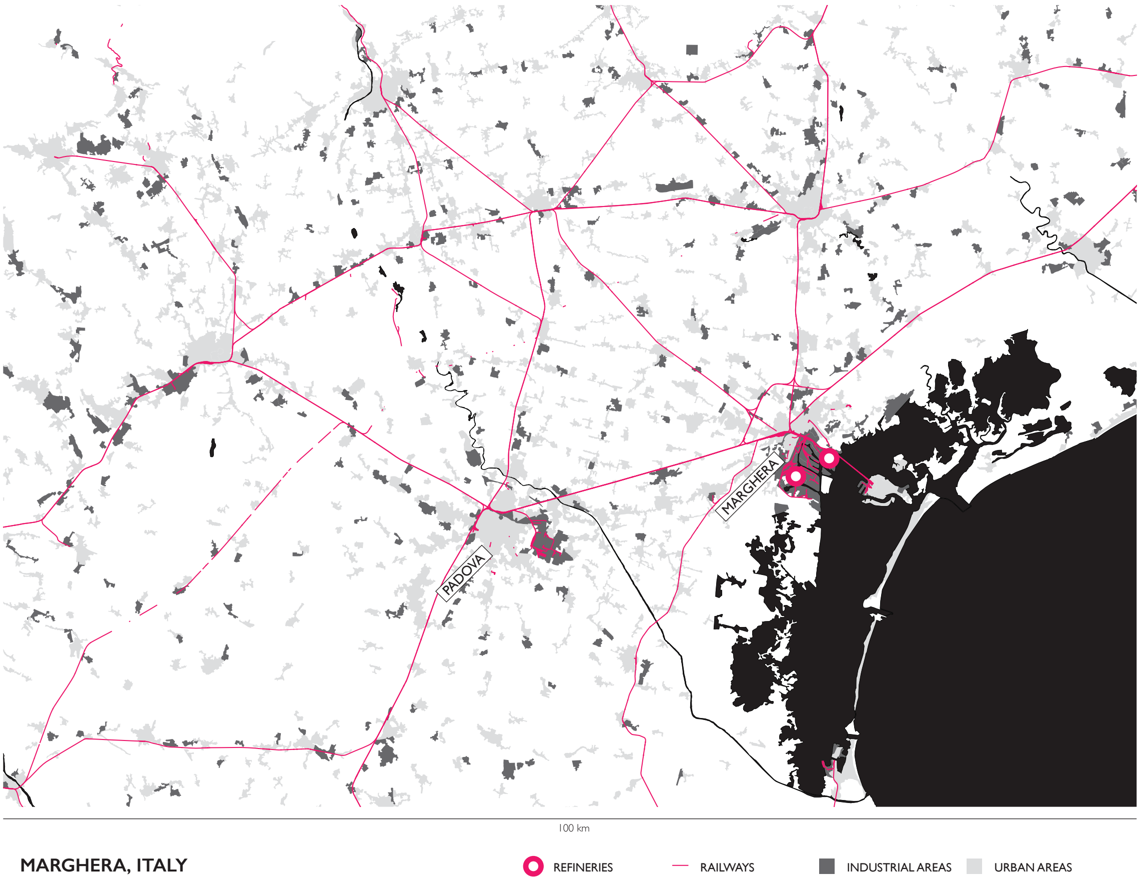


Fig. 24-25 Infrastructural development of the second industrial revolution (elaborated by the author, source: Corine Land Cover)

territorial density and their relationship with mining sites or refineries.
It is evident how the territories which experienced a massive infrastructural development during the first industrial revolution result to have a more dense and isotropic railway mesh, along which urban and industrial growth had primarily settled. On the contrary, the territories of the second industrial revolution are more affected by a stronger polarity in correspondence of fluvial or coastal industrial harbors where oil activities settled down, so having a primary dependency to water infrastructure rather than railways, which seem to constitute a secondary level which sprinkles territories in a more radial way that does not seem to have the same organizational attraction concerning industrial and urban agglutinations.

At present the massive transition towards renewable resources as primary source for energy production requires a more general energetic and mobility infrastructural reflexion. According to Rifkin (2011), if we look back to the transition from the first to the second industrial revolution, the implementation of coal infrastructures to oil ones took almost 50 years. If the transition from the second to the third industrial revolution should require the same time, we have to use this transition period to prepare our territories for the forthcoming radical shift.
As architects, we have the responsibility to foresee how the third industrial revolution could transform our landscapes and which kind of territorial hierarchies they will develop with their energetic and mobility infrastructure.

As a logical consequence of the contemporary awareness that territory is a non-renewable resource and its consumption has to be limited, Rifkin (2011) suggests that the *refurbishment of the existing building stock in micro-power plants* could represent a way to steer a distributed territorial energetic production together with the urban model for the third industrial revolution. Nevertheless, we notice that *garden city* and *sprawl* concepts convey a higher level of relational complexity among infrastructure, society and territories. In our opinion Rifkin's proposal focuses on a technical level, which can be correct, but it is not sufficient to describe the way our future landscapes will be planned according to the new economic models and how a distributed renewable energy production model, in contrast with a centralized one, could transform them.

The landscapes of the second industrial revolution

centralizedstructure

The two fossil fuels-based industrial revolutions were managed by a top-down hierarchical system, where only very few private pockets and public investors were able to build the necessary infrastructural network, so owning in most cases the entire energy processes, from resources' extraction to their processing and distribution to final consumers.

Three are the major components in which oil industry is normally subdivided:

- *upstream* corresponds to exploration and production activities. Conventional on-shore oil extraction is characterized by the typical *drilling wells*, which punctually harvest huge surfaces. The recent diffusion of new extraction technologies for conventional and non-conventional oil, such as *horizontal wells*, contribute in changing the usual vertical petroleum landmarks into flat surfaces, which scatter satellite images in a very peculiar pattern. Specially in the USA and in Canada, very expensive and invasive technologies in terms of energetic consumption and environmental damages are widely used to harvest *shale oil* and *tar sands*;
- *midstream* includes transportation activities of crude oil through different infrastructures (oil pipelines, rails, highways or waterways). It also involves storage and marketing activities for the delivery of crude or refined products to downstream distributors. Crude oil pipelines normally lie in the subsoil and they are physically materialized by non-building buffer zones. According to Neeraj Bhatia (2013, p. 274) pipelines are the interface between the territorial scale and architecture;
- *downstream* comprises the refining of crude oil activities and the processing of by-products. Refineries and petrochemical plants are the industrial architectural materialization of these processes, what Branzi (2006) calls the *cathedrals of modernity* of the energy domain. They occupy huge surfaces, which normally lie near watercourses and seaports, because water is a fundamental element for thermal energy production, crude oil desalting and for shipping facilities. These sites are normally characterized by the presence of high chimneys, storage tanks, highly technological buildings, an important network of pipes, fractionating columns to separate more volatile by-products frome those less through a process generally called *topping*, and even some huge voids.

Even if they are not considered a component of oil industry, *thermal power plants* are another frequent expression of oil or gas processing cycles in order to produce electricity. Processes are normally subdivided in three phases: *boilers*, which produce steam from water; *turbines,* driven by the steam flow; *condensers*, which transform the mechanical movement of turbines into electricity.

vertical oil drilling wells

Fig. 26 Oil Fields #2 Belridge, California, USA, 2003 (source: Edward Burtynsky)

Fig. 27 Belridge Oil fields, California, USA, altitude: 2.5 km (source: Google Earth 2017)

Fig. 28 Belridge Oil fields, California, USA, altitude: 800 m (source: Google Earth 2017)

vertical oil drilling wells

Fig. 29 Oil Fields #27 Bakersfield, California, USA, 2003 (source: Edward Burtynsky)

Fig. 30 Bakersfield Oil fields, California, USA, altitude: 2.5 km (source: Google Earth 2017)

Fig. 31 Bakersfield Oil fields, California, USA, altitude: 700 m (source: Google Earth 2017)

horizontal oil drilling wells

Fig. 32 The Marinz Project (source: Eltjon Valle)

Fig. 33 Patos Marinza horizontal wells, Fier, Albania, altitude: 5 km (source: Google Earth 2017)

Fig. 34 Patos Marinza horizontal wells, Fier, Albania, altitude: 1,5 km (source: Google Earth 2017)

tar sands

Fig. 35 Oil Sands #9 Fort McMurray, Alberta, Canada, 2007 (source: Edward Burtynsky)

Fig. 36 Fort McMurray tar sands, Alberta, Canada, altitude: 43 km (source: Google Earth 2017)

Fig. 37 Fort McMurray tar sands, Alberta, Canada, altitude: 8 km (source: Google Earth 2017)

oil pipelines

Fig. 38 Oil Fields #22 Cold Lake, Alberta, Canada, 2001 (source: Edward Burtynsky)

Fig. 39 Cold Lake oil fields, Alberta, Canada, altitude: 4 km (source: Google Earth 2017)

Fig. 40 Cold Lake oil fields, Alberta, Canada, altitude: 2 km (source: Google Earth 2017)

oil refineries

Fig. 41 Oil Refineries #34 Houston, Texas, USA, 2004 (source: Edward Burtynsky)

Fig. 42 Houston Oil refinery, Texas, USA, altitude: 10 km (source: Google Earth 2017)

Fig. 43 Houston Oil refinery, Texas, USA, altitude: 5 km (source: Google Earth 2017)

thermal power plants

Fig. 44 ENEL Thermal Power Plant, Polesine Camerini, Rovigo, Italy (source: Enel, Futur-E programme documentation)

Fig. 45 ENEL Thermal Power Plant, Polesine Camerie, Rovigo, Italy, altitude: 15 km (source: Google Earth 2017)

Fig. 46 ENEL Thermal Power Plant, Polesine Camerie, Rovigo, Italy, altitude: 3 km (source: Google Earth 2017)

A taxonomy of fossil fuel meshes on Adrion coasts

adrionstructure

Oil industry, with its three physical manifestations on territories (upstream, midstream and downstream infrastructures), is something that is completely intertwined with Adriatic coasts. Thanks to some GIS mapping tools, it was possible to measure the consistency of the oil industry in the Adrion macro-region. The following cartography shows the consistency and the distribution of the principal oil infrastructure along the Adriatic-Ionian coasts: every country (except for Montenegro) which belongs to Adrion macro region is concerned by at least one downstream plant in a coastal context.
Therefore, the main onshore oil and gas fields, coal mines, crude oil and gas pipelines, petroleum refining and processing sites and power plants have been identified in 8 case studies, 4 in Italy and 4 on the Eastern Adrion coasts.

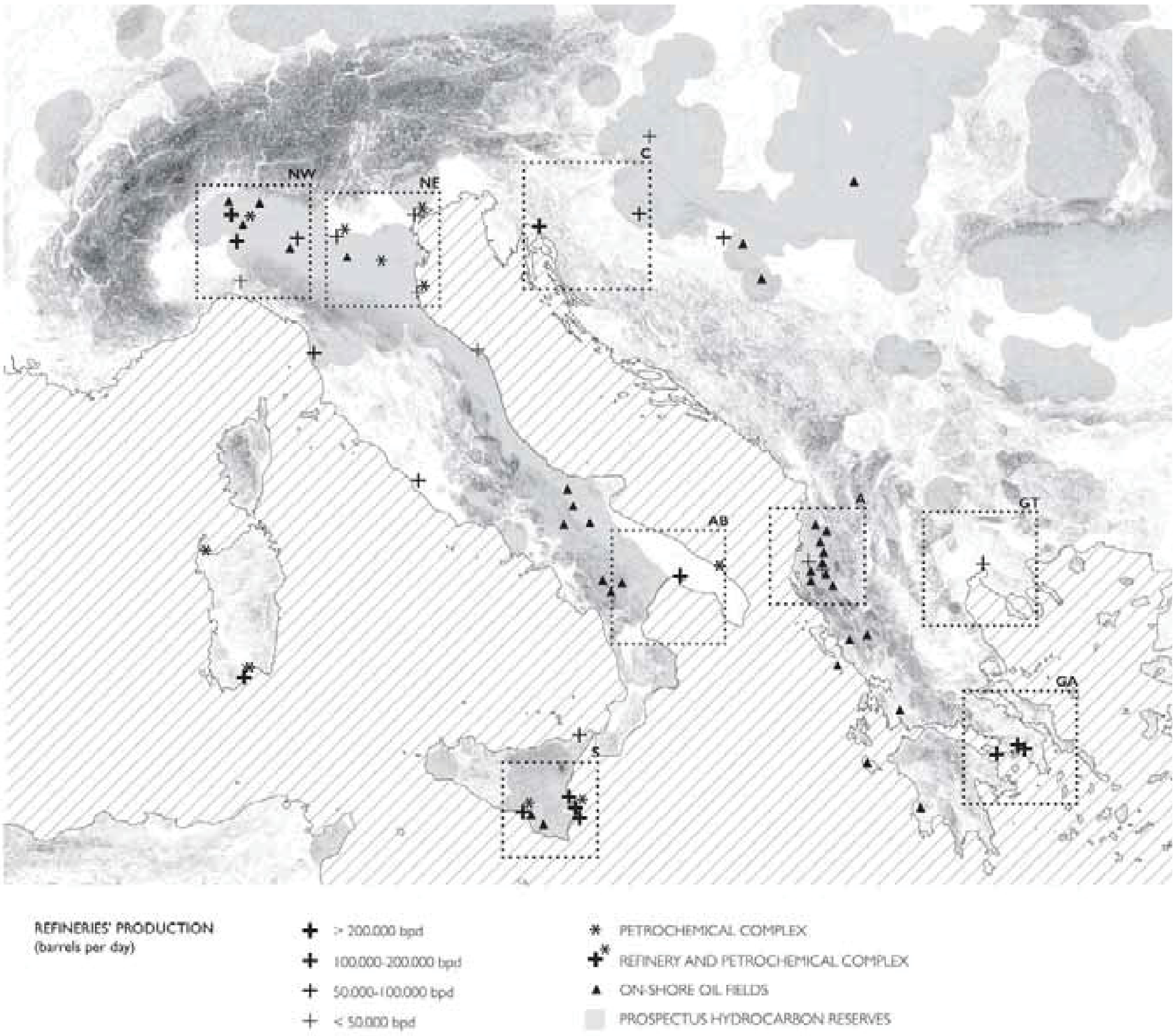


Fig. 47 Oil industry in Adrion region (elaborated by the author)

It is remarkable to notice the quantity of refining and petrochemical complexes along the Italian Adriatic coasts. Indeed, Italy has historically been a European leader in crude oil refining processes and petrochemical activities.
Since 1920s, Italian government adopted industrialization development strategies encouraging the settlement of chemistry, oil and energy industrial districts in depressed, less developed or unhealthy areas. The decision to settle Porto Marghera industrial harbour and oil activities on the inland territories of Venice province was the result of a specific socio-cultural thinking based on the conviction that industrial growth represented the opportunity to reclaim the unhealthy marshy wetlands of Venice Lagoon[6] and to solve the demographic pressure of the city and favor an improvement in the sanitary situation[7].
Other experiences concerning the application of industrialization development strategies in Italy date back to the 1930s in Ferrara and Brindisi provinces, when the settlement of petrochemical complexes represented the opportunity to create several local employments in underdeveloped regions, the same in Sicily (1950s) in order to reconstruct a devastated economy by World War II.

Another interesting territorial feature, we can highlight from the analysis of the maps, consists of the identification of two opposite tendencies which occurred on Adrion coasts: if, on the one hand, the Western coasts have historically been infrastructured through numerous downstream sites, the Eastern coasts have not developed a solid downstream sector, though they are richer in oil, gas and coal reserves that have never been fully exploited. In a short time the economic and ecological conscience completely changed and, starting from the first oil crisis in the 1970s until now, downstream oil sector on the Western Adrion coasts suffered a huge setback due to some structural reasons, such as (Oliva, 2014):

- very restrictive EU environmental laws that made the refining process more competitive in non-EU countries;
- very high energy costs in Western European countries;
- current geo-political instability in the Middle-East and North-Africa;
- massive substitution of oil with natural gas for energy production and for household heating;
- reduction of the demand for fuels and derived oil products because of a more and more rampant ecological sensitivity and awareness.

Oil and fossil fuel industry's perspectives on Eastern ADRION coasts are completely different. After World War II, most of Eastern European countries adhered to the *Communist Block* and, for decades, energy industry relied upon

6 See S. Barizza, *Dai Bottenighi a Marghera*. in Barizza Sergio, Resini Daniele (ed.), Portomarghera. Il Novecento industriale a Venezia, Ponzano, Grafiche Vianello, 2004, pp. 29-33

7 see G. Zanon, *Dal sovraffollamento all'esodo: popolazione ed occupazione a Venezia nel '900*, in Venezia Novecento, special number of 'Quaderni' di Insula, Anno II n.4, Venezia 2000, pp. 19- 32.

Soviet resources for an internal market. At the beginning of the 1990s, with the fall of the Berlin wall, the subsequent dissolution of URSS in sovereign nations and the advent of capitalist market, some of the more antiquated Eastern European refineries have been having some difficulties staying in operation, due to the backwardness of productive systems and their non-adaptability to the rigid EU laws as to pollution and environmental protection. The long-term profitability of those refineries which faced high costs for a modernization process has been tragically weakened by the global economic crisis since 2008. In the meanwhile, most of the Eastern Europe fossil fuel potential has not been explored and exploited yet. Liberal market brought private investors investing in exploration and production oil activities, but they prefer to export the harvested fossil fuel and refine it elsewhere rather than updating the internal refining production, as for Albanian oil industry case study.
In a near future, we are going to face two different situations concerning oil industry on the Adriatic-Ionian coasts: a progressive contraction of downstream activities on Western coasts and a flourishing implementation of non-conventional oil production on the Eastern ones.

The taxonomy of fossil fuel meshes which lie along the Adrion coasts has the objective of making a state of the art of the existing hydrocarbons infrastructure and wants to identify the principal private and public actors involved, so as to lay the foundations for a necessary networking activity capable of implementing future private-public funded research.

Important notes about the elaboration of the maps:
The cartographical mapping of the 8 case studies merges some GIS metadata, in particular geographical information extrapolated from Corine Land Cover 2012 database[8] (urban and industrial areas, water infrastructure), with underground fossil fuel infrastructure, which have been recovered from national and private operators' websites. Due to the lack of the availability of some fossil fuel infrastructure metadata, our cartographies have been implemented matching GIS information with schematic raster images. Consequently, in some cases the geographical accuracy of the real geometry and path of underground infrastructure cannot be guaranteed, but we do not believe that this will negatively influence the results of the research and the quality of the analysis. In fact, what is considered fundamental for the research and is guaranteed by crossing different sources consists in identifying the nodes of the oil mesh which are

8 CORINE (Coordination of Information on the Environment) Land Cover is a programme supported by EEA (European Environment Agency) since 1985 aimed to draw up a mapping inventory of land cover uses, subdivided in 44 classes, on the whole European territory. Four have been the updates up to now: CLC 1990, CLC 2000, CLC 2006 and CLC 2012. Corine Land Cover is a free GIS tool downloadable on the website: www.eea.europa.eu

concerned by specific infrastructural interconnections and in the defining the type of relation within the nodes.

Another important element that is worth to be mentioned concerns the nature of fossil fuel data: in fact, cartographies don't focus only on oil infrastructure, but they want to give a general overview about fossil fuel infrastructure in a broader way, so integrating even gas and coal upstream and midstream infrastructure. Fossil fuel infrastructure will be analyzed at a territorial scale, while oil ones will be further deepened at a landscape and urban planning scale.

The main criterion for the definition of our *territorial portions* has been led by the physical territorial density of fossil fuel infrastructure and its interrelationships in 3 territorial extensions: 100x100 km, 150x150 km and 200x200 km. We consider that the above-mentioned dimensions integrate transregional dependencies among the nodes of the meshes, so allowing us to implement some reflexions about the necessity to overcome the administrative boundaries in order to propose new territorial planning tools, as carried on by Italian urbanist Giuseppe Samonà in the 1960s and that will be dealt with in the following chapters[9].

9 We are referring to Samonà's notion of *Comprensorio regionale (regional district)* experienced for the local development plan of Polesine's municipalities in 1961.

NW

North-Western Po Valley fossil fuel mesh

Some of the few Italian oil fields are dislocated in the North-Western Po Valley area, in particular along the course of Po River, between Piacenza and Cremona, and along the Ticino River, near Trecate, in the province of Novara. Not by chance this is a very rich area in terms of oil infrastructure. In fact, four refineries are settled in this area, and three of them along Ticino and Po River, in proximity of the above-mentioned oil fields.

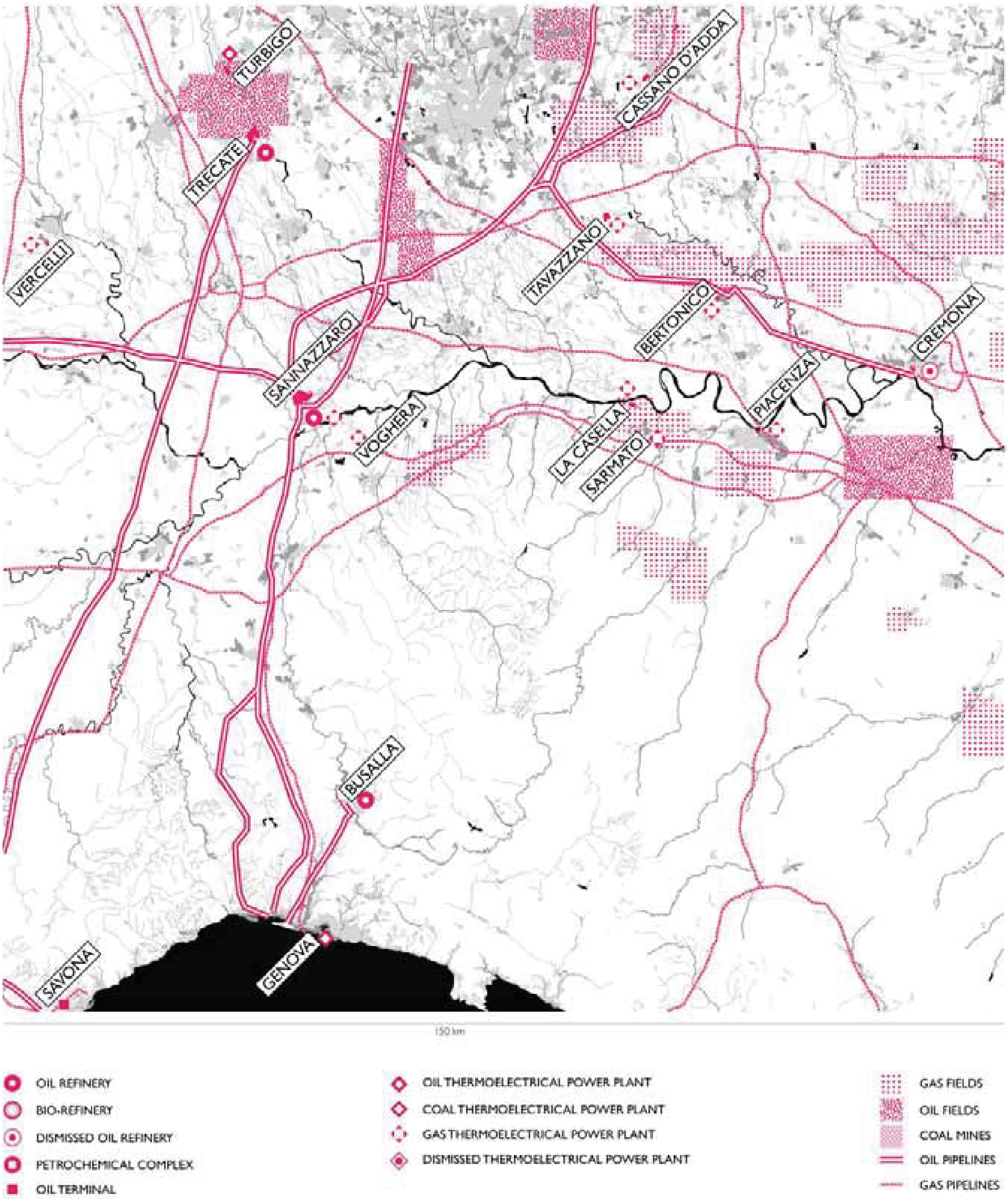
The Sannazzaro de Burgondi oil refinery, operated by ENI, lies along the pipeline connecting the oil terminal in Genoa to the Swiss refinery in Collombey (Valais) now dismissed. The crude oil coming from Genoa terminal mainly arrives from Russia, Africa, North Europe and Middle East regions and represents about 90% of crude oil treated in the complex. The remaining quantity is an internal oil production from Villafortuna oil fields, near Trecate.

The Exxon Mobil / ERG Trecate refinery, one of the most efficient on the Italian territory, is connected with a 150 km long pipeline to the oil storage tanks in Savona, so making imported oil the most relevant source for Trecate refinery activities.

IPLOM refinery, located near Busalla, along Scrivia River and part of the metropolitan area of Genoa, is directly connected to Genoa harbour and powered by an oil pipeline.

The Tamoil Cremona refinery is the only dismissed refinery in the considered area (in 2011) and lies on the Po river banks. It is connected to the principal pipeline going to Switzerland by a secondary branch, along which two combined natural gas and oil power plants in Bertonico and in Tavazzano are situated.

Some gas fields south-east from Milan and others south-west from Piacenza are also connected to the Italian natural gas grid.



sources: **Geographical metadata**

- Corine Land Cover 2012 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

Fossil fuels metadata and information

- Italian Economic Development Ministry metadata: http://unmig.mise.gov.it/unmig/titoli/elenco.asp?tipo=ICT
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org;
- ENI oil and gas pipelines: ENI factbook 2014: http://www.eni-italy.info/ENI_Web/World-Oil-Refineries-List.htm
- EXXON infrastructures' information: http://corporate.exxonmobil.com;
- IPLOM infrastructures' information: http://iplom.it;
- EON power plants' information: www.eon-italia.com/it.html;
- TAMOIL infrastructures' information: http://www.tamoil.com

Ortophotos

- Google Earth

PRINCIPAL DOWNSTREAM SITES

EXXON MOBIL/ERG TRECATE OIL REFINERY

START-UP DATE	1948
OPERATING COMPANY	Exxon Mobil / ERG Petroli
STATUS	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	200'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- CRUDE OIL IS TRANSPORTED BY TANKERS TO BUOYS AT VADO LIGURE, SAVONA - AN UNDERGROUND PIPELINE (150 km long) CONNECTS THE COASTAL QUILIANO STORAGE TANKS WITH THE REFINERY

ENI SANNAZZARO DE BURGONDI OIL REFINERY

START-UP DATE	1963
OPERATING COMPANY	ENI Italy
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	170'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- MAINLY SUPPLIES BY-PRODUCTS' MARKET IN NORTH-WESTERN ITALY AND SWITZERLAND

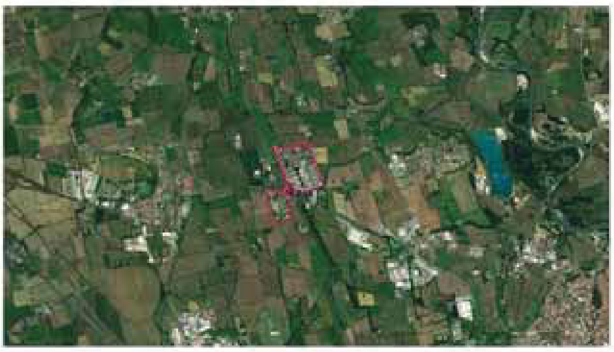
IPLOM BUSALLA OIL REFINERY

START-UP DATE	1945
OPERATING COMPANY	IPLOM
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	40'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	-

TAMOIL CREMONA OIL REFINERY

START-UP DATE	-
OPERATING COMPANY	TAMOIL GROUP
STATUS OF COMPLEX	DISMISSED, USED AS DEPOSIT
TYPE	CRUDE OIL REFINERY
CAPACITY	96'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- STORAGE CAPACITY IS 100 TANKS

PRINCIPAL POWER PLANTS



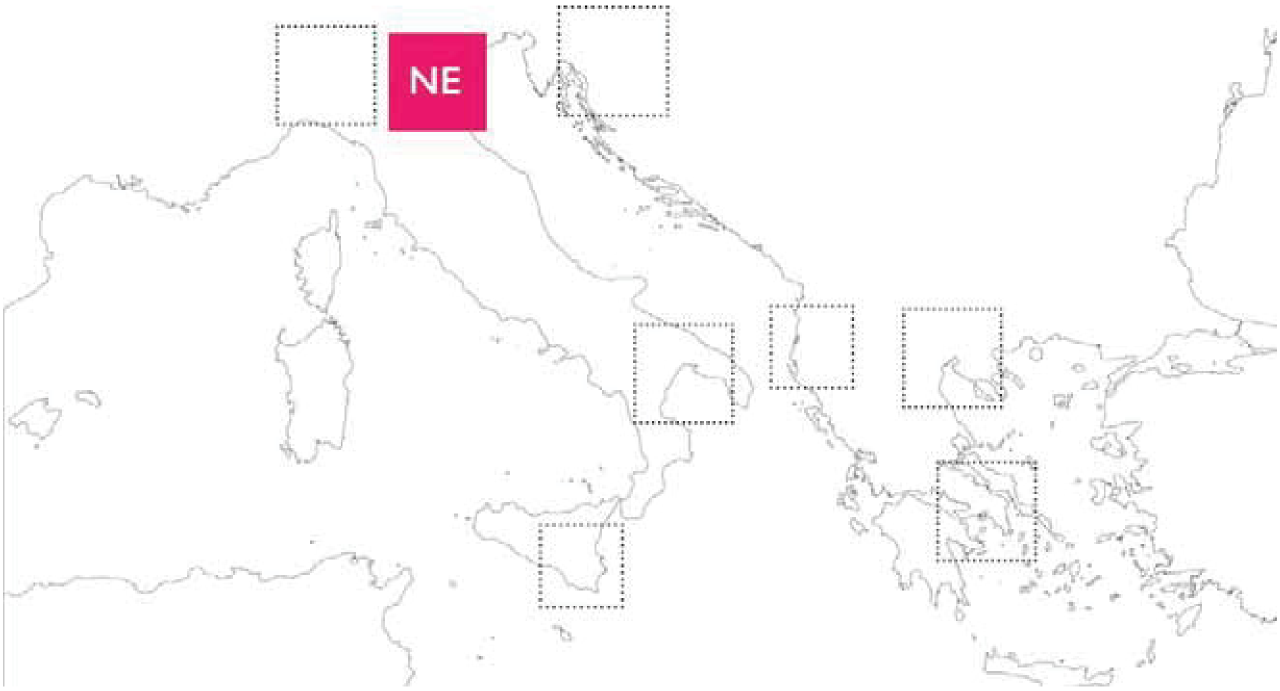
10 km

E.ON TAVAZZANO CCGT POWER PLANT

START-UP DATE	1952
OPERATING COMPANY	E.ON Italia
STATUS	OPERATING
TYPE	COMBINED CYCLE GAS TURBINE
TYPE OF FUEL	NATURAL GAS + FUEL OIL
SOURCE OF FUEL	NATIONAL GAS GRID
CAPACITY	1'740 MW
PRINCIPAL FEATURES	-

NE

North-Eastern Po Valley fossil fuel mesh



The North-Eastern Po valley is one of the richest region in terms of fossil fuel infrastructure in the Italian territory.

Emilia-Romagna's eastern plain was a quite important provider for the upstream sector, due to the natural gas fields in the subsoil which scattered the agricultural pattern, most of which are currently depleted.

From a downstream point of view, four are the sites still operating in the area, distributed on three different regions:

• the first and the most ancient one is Porto Marghera industrial harbor (Venice), where a huge petrochemical complex is still working, even if a slow dismissing process has already started and will probably last over the next years due to the crisis of the downstream sector in Europe. Moreover, an ancient and underperforming crude oil refinery has been converted, in 2014, in a bio-refinery for the bio-diesel production by imported palm-oil;

• the petrochemical complex in the suburbs of Ferrara that is partially still working;

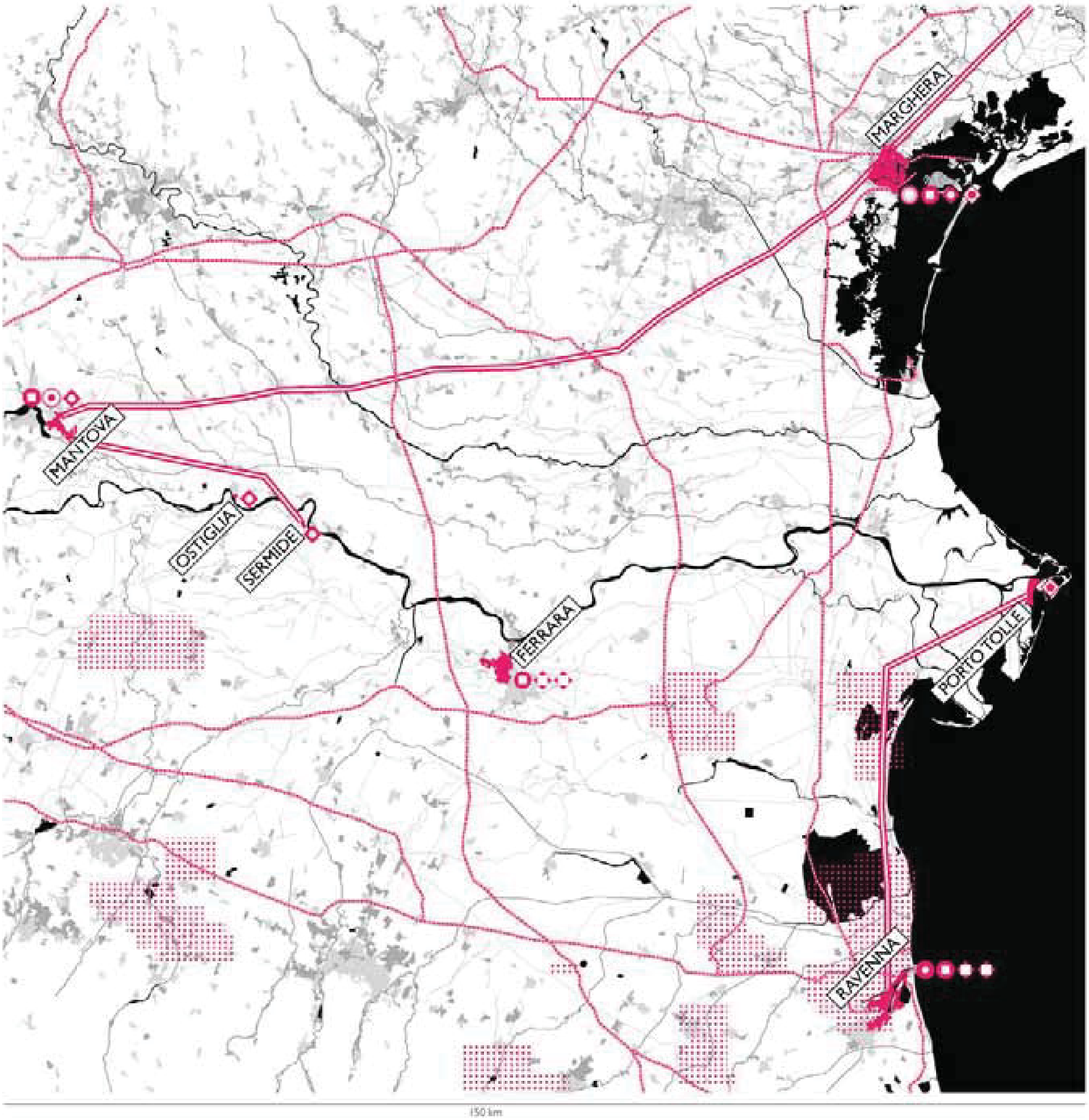
• a refinery and a petrochemical site inside Ravenna harbour, both in function;

• a dismissed oil refinery in Mantua, currently used only as a storage for by-products refined in Porto Marghera.

Energy industry is tightly tied to downstream oil sites and it is often combined with refineries and petrochemical sites. Two are the power plants in Porto Marghera industrial area, both fuelled by coal and oil: the Giuseppe Volpi power plant (160 MW, currently dismissed) and the still working Andrea Palladio one (976 MW). Even in Ravenna it is possible to identify two functioning thermal power plants (750 MW and 785 MW), in Ferrara (510 MW and 150 MW) and only one in Mantua site (510 MW). Moreover, three independent thermal power plants are located in more isolated areas: two are still working in proximity of the river Po, near the town of Sermide (1'154 MW) and Ostiglia (1'140 MW), and the other one, nowadays dismissed, in the locality of Polesine Camerini, in the very middle of the fragile eco-system of the Po delta river (2'640 MW).

Some of the above-mentioned fossil fuel infrastructure are interrelated by underground oil pipelines: some oil tanks in Ravenna harbour fed the power plant in Polesine Camerini, while the refinery in Porto Marghera is connected to the one in Mantua.

A dense national gas pipeline network catches natural gas fields' production in Emilia Romagna and is connected to the first Italian offshore LNG in Porto Viro.



OIL REFINERY
BIO-REFINERY
DISMISSED OIL REFINERY
PETROCHEMICAL COMPLEX
OIL TERMINAL

OIL THERMOELECTRICAL POWER PLANT
COAL THERMOELECTRICAL POWER PLANT
GAS THERMOELECTRICAL POWER PLANT
DISMISSED THERMOELECTRICAL POWER PLANT

GAS FIELDS
OIL FIELDS
COAL MINES
OIL PIPELINES
GAS PIPELINES

sources:

Geographical metadata
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

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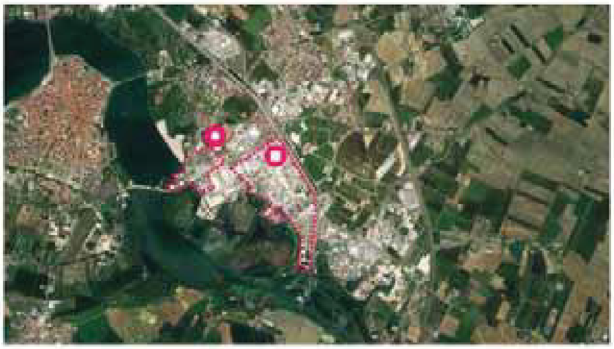
- Italian Economic Development Ministry metadata: http://unmig.mise.gov.it/unmig/titoli/elenco.asp?tipo=ICT
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org;
- ENI oil and gas pipelines: ENI factbook 2014: http://www.eni-italy.info/ENI_Web/World-Oil-Refineries-List., https://www.eni.com/it_IT/innovazione/piattaforme-tecnologiche/green-refinery.page;
- ALMAPETROLI infrastructures' information: http://www.almapetroli.com/index.php/it/home-4/;
- IES infrastructures' information: https://molgroupitaly.it/it/mol-group-italy/mol-group-italy-chi-siamo/ies-italiana-energia-e-servizi;
- ENEL power plants' information: https://www.enel.it/it/futur-e.html;
- A2A power plants' information: http://www.a2a.eu

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES



IES MANTUA OIL REFINERY

START-UP DATE	1946
OPERATING COMPANY	MOL Group Hungary
STATUS	DIMSISSED, USED AS DEPOSIT
TYPE	CRUDE OIL REFINERY + PETROCHEMICAL ACTIVITIES (VERSALIS)
CAPACITY	55'000 barrels/day
SOURCE OF WATER	LAGO INFERIORE, MINCIO RIVER
PRINCIPAL FEATURES	- THE CRUDE OIL IS TRANSPORTED BY TANKERS THAT ARE DISCHARGED AT THE IES COASTAL TERMINAL IN PORTO MARGHERA (PIPELINE: 120 km LONG) - AS AN AREA OF HIGH ENVIRONMENTAL RISK, SINCE 1998 THE SITE IS CONSIDERED A SITE OF NATIONAL INTEREST "S.I.N. LAGHI DI MANTOVA"

ALMA PETROLI RAVENNA REFINERY

START-UP DATE	1960
OPERATING COMPANY	ALMA PETROLI
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY + PETROCHEMICAL ACTIVITIES (VERSALIS)
CAPACITY	75'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- THE REFINERY MAINLY PRODUCES BITUMEN

ENI PORTO MARGHERA OIL REFINERY

START-UP DATE	1926
OPERATING COMPANY	ENI
STATUS OF COMPLEX	OPERATING
TYPE	BIO-REFINERY + PETROCHEMICAL ACTIVITIES (VERSALIS)
CAPACITY	80'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- AS AN AREA OF HIGH ENVIRONMENTAL RISK, SINCE 1998 THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. PORTO MARGHERA" - IN 2014, PORTO MARGHERA REFINERY WAS CONVERTED IN A BIO-REFINERY, AND PRODUCES BIO-FUELS BY PALM OIL

PRINCIPAL POWER PLANTS

EDIPOWER SERMIDE CCGT POWER PLANT

START-UP DATE	1981
OPERATING COMPANY	EDISON - A2A
STATUS OF COMPLEX	OPERATING
TYPE	COMBINED CYCLE GAS TURBINE
TYPE OF FUEL	NATURAL GAS + FUEL OIL
CAPACITY	1'140 MW
SOURCE OF WATER	PO RIVER
SOURCE OF FUEL	GAS NATIONAL GRID
PRINCIPAL FEATURES	-

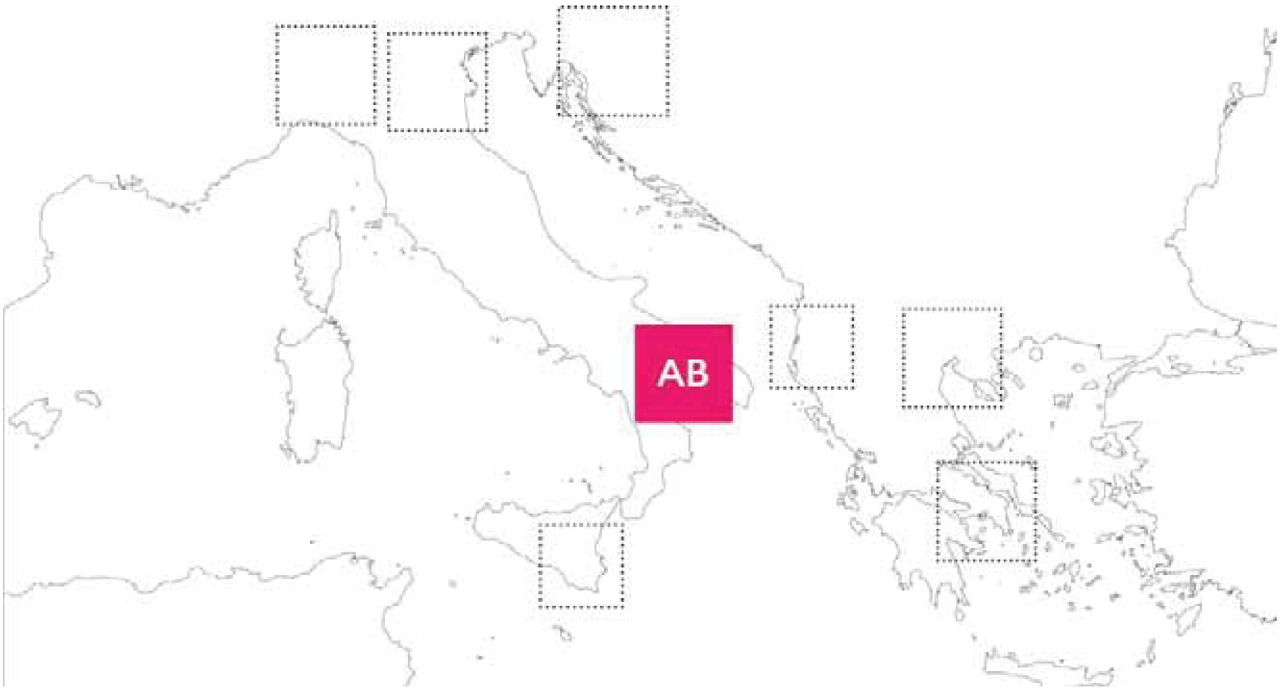
10 km

ENEL PORTO TOLLE THERMAL POWER PLANT

START-UP DATE	1980
OPERATING COMPANY	ENEL
STATUS OF COMPLEX	DIMISSED
TYPE	SUB-CRITICAL STEAM TURBINE
TYPE OF FUEL	HEAVY OIL, ORIMULSION
CAPACITY	2'640 MW
SOURCE OF WATER	PO RIVER
SOURCE OF FUEL	OIL PIPELINE FROM RAVENNA HARBOUR (90 km LONG)
PRINCIPAL FEATURES	-

AB

Apulia and Basilicata fossil fuel mesh



Basilicata is the Italian richest region in oil reserves. Two are the renowned oil fields of the Southern Apennine region:

• Val d'Agri, considered the Western Europe's most promising onshore oil field, which is explored by ENI;

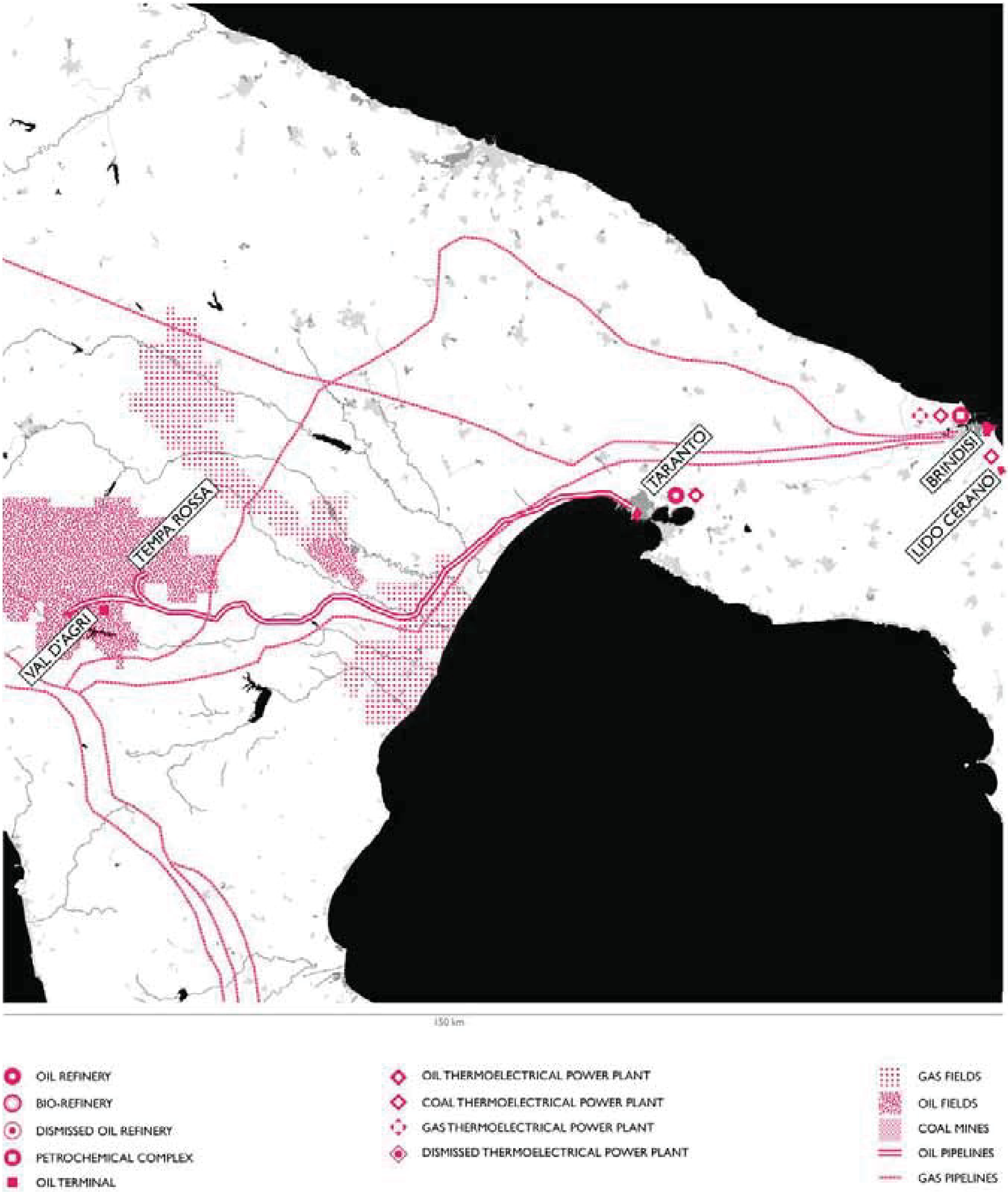
• Tempa Rossa, exploited by Total and ExxonMobil.

Centro Oli Val d'Agri in Viggiano is a preliminary separation center for natural gas, oil and water operated by ENI, where oil and gas are stabilized and then transported to Taranto refinery by the mean of a 140 km long oil pipeline, completed in 2001.

On the Eastern Adriatic coasts, a huge petrochemical complex, identical to that of Porto Marghera, was settled in the outskirts of Brindisi and represents one of the biggest industrial areas that has been realized in Southern Italy until now.

Not far from Brindisi petrochemical site, a huge coal power plant (ENEL Federico II power plant) was built at the beginning of the 1990s in Lido Cerano and, with its production capacity of 2'640 MW, it is the second biggest thermal power plant in Italy and one of the biggest in Europe. A 200 m high chimney unmistakably marks the territory.

The Trans Adriatic Pipeline, a future 3'500-kilometre long transregional natural gas infrastructure which would have to cross Italy, Albania, Greece, Turkey until the Caspian Sea, will stop at the gas reception terminal in Melendugno, entering for only 8 km in the Italian territory.



sources: **Geographical metadata**

- Corine Land Cover 2012 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

Fossil fuels metadata and information

- Italian Economic Development Ministry metadata: http://unmig.mise.gov.it/unmig/titoli/elenco.asp?tipo=ICT
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org;
- ENI oil and gas pipelines: ENI factbook 2014; https://www.eni.com/eni-basilicata/attivita/impianti-eni-in-basilicata/impianti-eni-in-basilicata.shtml; http://www.osservatoriovaldagri.it/web/guest/descrizione-dell-impianto; https://www.eni.com/docs/it_IT/eni-com/documentazione-archivio/documentazione/brochure/Taranto_281013_1-1.pdf; http://atlanteitaliano.cdca.it/conflitto/raffinazione-del-petrolio-a-taranto;
- TOTAL infrastructures' information: http://www.it.total.com/it/pagine/attivita/il-progetto-tempa-rossa;
- ENEL power plants' information: https://it.wikipedia.org/wiki/Centrale_ENEL_Federico_II;
- VERSALIS petrochemical activies' information: https://www.versalis.eni.com

Ortophotos

- Google Earth

PRINCIPAL DOWNSTREAM SITES

ENI TARANTO OIL REFINERY

START-UP DATE	1967
OPERATING COMPANY	ENI Italy
STATUS	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	110'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- PRODUCTION OF FUELS FOR AUTOMOTIVE USE FOR THE SOUTHERN ITALIAN MARKETS - REFING OF CRUDE OIL HARVESTED BY ENI IN TEMPA ROSSA AND VAL D'AGRI FIELDS, TRANSPORTED TO TARANTO BY MONTE ALPI OIL PIPELINE - AS AN AREA OF HIGH ENVIRONMENTAL RISK, THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. TARANTO"

CENTRO OLI VAL D'AGRI

START-UP DATE	2001 (extension of Centro Olio Monte Alpi)
OPERATING COMPANY	ENI spa (66%) and Shell Italia E&P spa (34%)
STATUS OF COMPLEX	OPERATING
TYPE	CENTRE FOR THE SEPARATION OF HYDROCARBONS AND NATURAL GAS
CAPACITY	104'000 barrels/day of oil 3'100'000 Sm^3/day of natural gas
SOURCE OF WATER	-
PRINCIPAL FEATURES	- COLLECTION OF THE PRODUCTION OF 27 OIL WELLS THROUGH UNDERGROUND PIPELINES - TREATMENT AND SEPARATION OF THE MULTIPHASE MIXTURE CONTAINING DIFFERENT PROPORTIONS OF OIL, NATURAL GAS AND WATER

PETROCHEMICAL POLE IN BRINDISI

START-UP DATE	1962
OPERATING COMPANY	VERSALIS spa
STATUS OF COMPLEX	OPERATING
TYPE	PETROCHEMICAL POLE
CAPACITY	
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- STEAM CRACKING - AS AN AREA OF HIGH ENVIRONMENTAL RISK, THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. BRINDISI"

PRINCIPAL POWER PLANTS

ENEL BRINDISI SUD COAL POWER PLANT IN LIDO CERANO

START-UP DATE	1991
OPERATING COMPANY	ENEL spa
STATUS OF COMPLEX	OPERATING
TYPE	SUB-CRITICAL PLANT
TYPE OF FUEL	COAL - HEAVY FUEL OIL - ORIMULSION
DESIGN CAPACITY	2'640 MW (4x660 MW)
SOURCE OF COAL	BY CONVEYOR FROM BRINDISI COAL PORT
SOURCE OF COOLING WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- CHIMNEY 200 m HIGH

PRINCIPAL UPSTREAM SITES

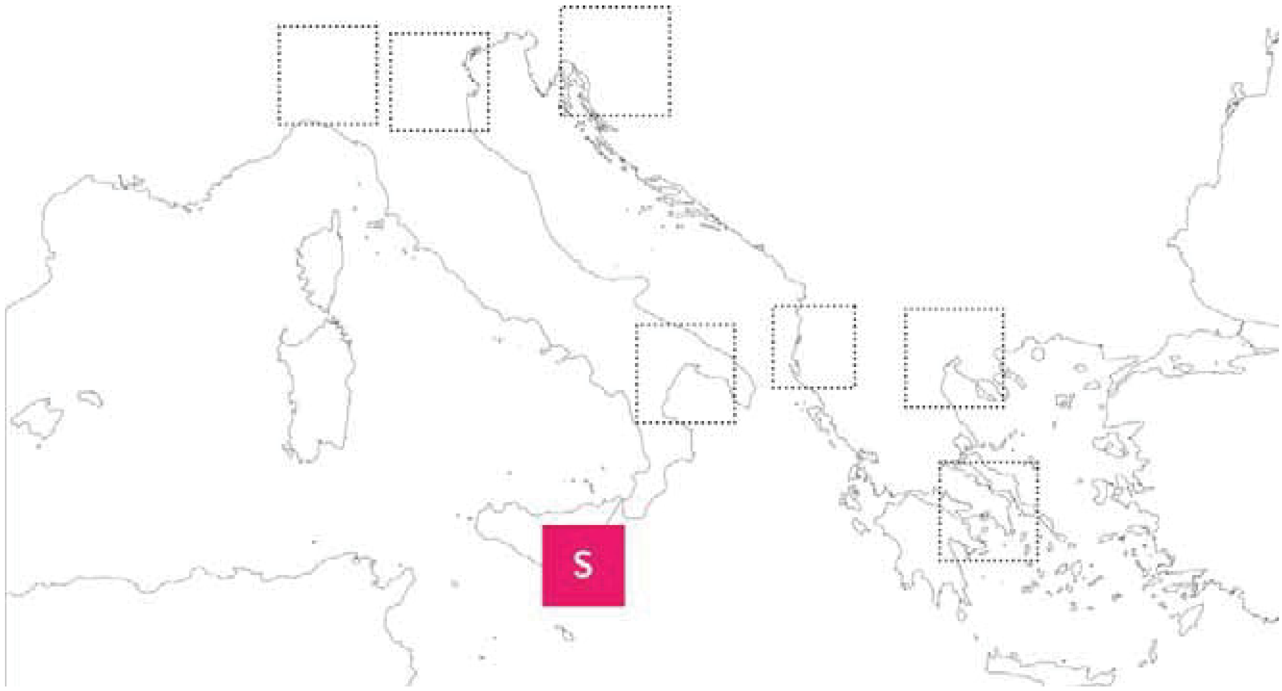
10 km

TEMPA ROSSA OIL FIELDS

START-UP DATE	1989
OPERATING COMPANY	TOTAL E&P Italia
STATUS OF COMPLEX	OPERATING
TYPE	HEAVY OIL
DESIGN CAPACITY	50'000 barrels/day of oil + 230'000 m^3/day of natural gas + 240 t/day of GPL + 80 t/day of sulfur
PRINCIPAL FEATURES	- LOCATED BETWEEN THE REGIONAL PARK OF GALLIPOLI COGNATO AND POLLINO NATIONAL PARK - EXTENDED OVER A GEOLOGICAL TERRITORY MARKED BY A NOT NEGLIGIBLE SEISMICITY AND BY A COMPLEX HYDROGEOLOGICAL NETWORK - ARCHAEOLOGICAL HERITAGE IN THE SURROUNDIGS

S

Sicilian fossil fuel mesh



In a very concentrated area, comprised between Gela and Syracuse, oil infrastructure has historically shaped one of its most relevant expression.
At the end of World War II, Sicilian economic and social situation was catastrophic. In those years, a big industrialization development plan encouraged the settlement of innovative technological industries in the South-Eastern Sicily. In 1949, the first refining plant was settled in Augusta and, until the end of '70s, two other petrochemical plants were built in Priolo Gargallo and in Melilli, so completely saturating the Augusta bay.

Thanks to Enrico Mattei's initiative in the 1960s, Gela refinery saw the light to take advantage of the close oil fields. Thus, four refineries (Gela, Priolo Gargallo, Melilli and Augusta) and two petrochemical sites (Gela and Priolo Gargallo) are currently located in the South-Eastern area, within a radius of 100 km. In 2014 ENI stopped the refining activities in Gela site and began the procedures for its conversion into a green refinery for bio-fuel production.

In the province of Syracuse, since the 1950s, railway network has been implemented in order to connect Ragusa's oil fields to Augusta's refining plants, before the realization of the crude oil pipeline. Meanwhile, Augusta harbour's infrastructure was expanded in order to improve the reception of oil tankers.

Upstream onshore sites are mostly concentrated in two areas of the territory (Ragusa and Gela), and have been explored since 1930s. Recently, oil exploration's horizons widened and unexplored huge areas could be interested in the near future by new extraction activities.

Some crude oil pipelines unfold from central Sicilian oil and gas fields in Gagliano Castelferrato to Gela refinery, and from Ragusa oil fields to oil refining plants located near Syracuse.

The Greenstream is a 520 km long gas pipeline, built in 2004, which connects Libyan Bahr Essalam offshore and Waha onshore gas fields to South-Eastern Sicilian coasts, reaching the gas terminal in Gela, and from here natural gas is entered into the Italian national gas grid.

- OIL REFINERY
- BIO-REFINERY
- DISMISSED OIL REFINERY
- PETROCHEMICAL COMPLEX
- OIL TERMINAL
- OIL THERMOELECTRICAL POWER PLANT
- COAL THERMOELECTRICAL POWER PLANT
- GAS THERMOELECTRICAL POWER PLANT
- DISMISSED THERMOELECTRICAL POWER PLANT
- GAS FIELDS
- OIL FIELDS
- COAL MINES
- OIL PIPELINES
- GAS PIPELINES

sources:

Geographical metadata
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

Fossil fuels metadata and information
- Italian Economic Development Ministry metadata: http://unmig.mise.gov.it/unmig/titoli/elenco.asp?tipo=ICT
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org
- ENI oil and gas pipelines: ENI factbook 2014: http://www.eni-italy.info/ENI_Web/World-Oil-Refineries-List., https://www.eni.com/it_IT/media/dossier/nuovo-piano-sviluppo-gela.page
- ISAB infrastructures' information: http://www.isab.com/isab/?p=home&s=storia
- EXXON MOBIL infrastructures' information: http://local.esso.it/Italy-Italian/PA/about_what_refinery_augusta.aspx

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES

EXXON MOBIL AUGUSTA OIL REFINERY

START-UP DATE	1949
OPERATING COMPANY	Exxon Mobil
STATUS	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	190'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- MAIN CRUDE OIL RECEPTION BY THE SEA - IN 1957 AN OIL PIPELINE WAS BUILT TO CONNECT THE REFINERY WITH THE RAGUSA OIL FIELDS - AS AN AREA OF HIGH ENVIRONMENTAL RISK, SINCE 1998 THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. PRIOLO"

ISAB ERG IMPIANTI NORD OIL REFINERY, MELILLI

START-UP DATE	1956
OPERATING COMPANY	ERG
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	160'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- AS AN AREA OF HIGH ENVIRONMENTAL RISK, SINCE 1998 THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. PRIOLO"

ISAB ERG IMPIANTI SUD OIL REFINERY, PRIOLO GARAGLLO

START-UP DATE	1975
OPERATING COMPANY	ERG
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY + PETROCHEMICAL ACTIVITIES
CAPACITY	214'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- AS AN AREA OF HIGH ENVIRONMENTAL RISK, SINCE 1998 THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. PRIOLO"

ENI GELA OIL REFINERY

START-UP DATE	1963
OPERATING COMPANY	ENI spa
STATUS OF COMPLEX	OPERATING
TYPE	ONGOING TRANSFORMATION INTO A BIO-REFINERY
CAPACITY	100'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- IT MAINLY PROCESSED OIL COMING FROM OFFSHORE AND SHORE SICILIAN OIL FIELDS - IN 2014 ENI COMPLETELY STOPPED THE OIL REFINING PROCESS AND BEGAN THE RECONVERSION OF THE PLANT INTO A BIO-REFINERY - AS AN AREA OF HIGH ENVIRONMENTAL RISK THE SITE IS CONSIDERED AS A SITE OF NATIONAL INTEREST "S.I.N. GELA"

PRINCIPAL POWER PLANTS

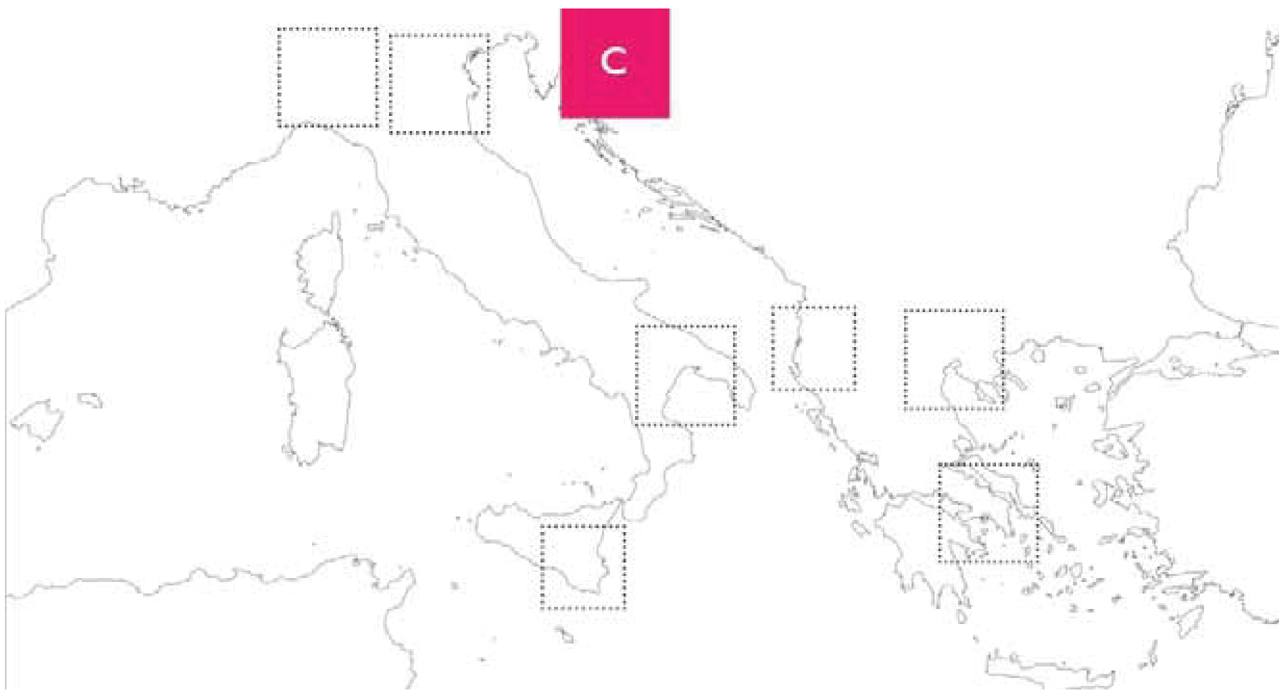
10 km

ISAB PRIOLO GARGALLO IGCC POWER PLANT

START-UP DATE	-
OPERATING COMPANY	ERG + EDISON
STATUS OF COMPLEX	OPERATING
TYPE	COMBINED CYCLE GAS TURBINE
TYPE OF FUEL	SYNGAS FROM REFINERY RESIDUAL OIL
CAPACITY	560 MW
SOURCE OF WATER	MEDITERRANEAN SEA
SOURCE OF FUEL	RESIDUAL OIL FROM ISAB ERG OIL REFINERY
PRINCIPAL FEATURES	-

C

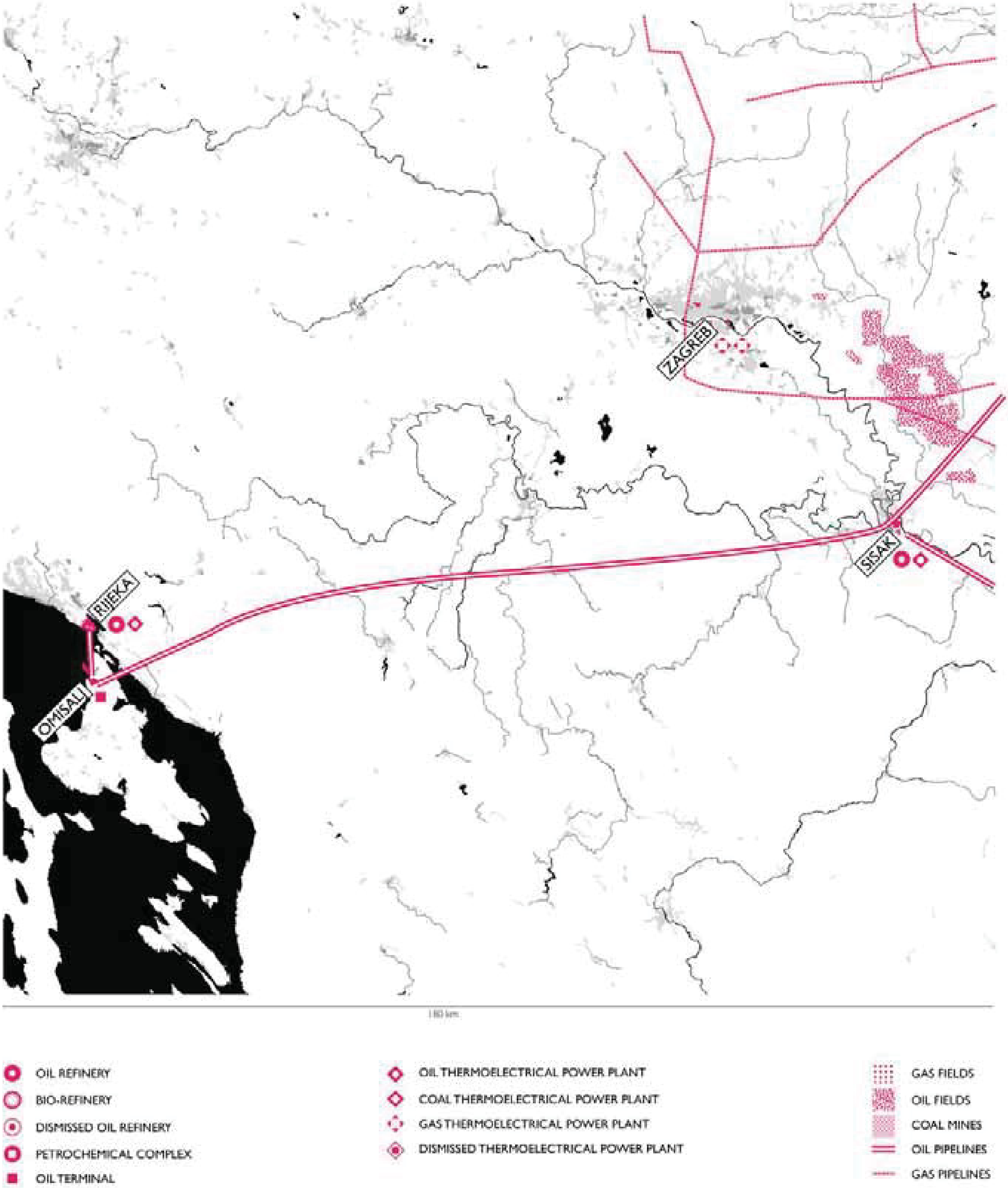
Croatian fossil fuel mesh



Two still operating refineries are settled in Croatia, precisely in Rijeka and Sisak. The Sisak refinery is principally supplied by Russian crude oil via the Druzhba pipeline, the world's longest oil pipeline with its 4'000 km long which crosses Eastern Europe starting from Almetyevsk in Tatarstan (Russia), where it collects crude oil from Western Siberia, the Urals and the Caspian Sea, and passes through Belarus, Ukraine, Hungary, Poland, Slovakia, the Czech Republic and Germany. The construction of the principal line started in 1960 and was fully operating in 1964.

The crude oil Omišalj Terminal, situated on Krk Island, in front of Rijeka refinery, constitutes the starting point of the Adria crude oil pipeline and is fuelled by oil tankers arriving from the Adriatic Sea. Since 1964, the construction of the Adria oil pipeline had been discussed in order to supply Yugoslav refineries in Croatia, Bosnia and Herzegovina, Serbia, through a branch line which would have reached the Hungarian border, passing through Ljubljana. In 1968, the decision of Austrian government to invest in the connection to Trieste-Ingolstadt pipeline made caduceus the possibility to develop the Northern branch of Adria oil pipeline towards Austria, Czechoslovakia and Poland, which, in turn, looked at the expansion of Druzhba pipeline with more interest. The current configuration of Adria pipeline was designed in 1973 and a joint committee of Yugoslavia's three biggest oil companies (INA, Energoinvest and Naftagas) named JANAF was in charge to manage the operability of the oil pipeline. Only in 1984 the pipeline started to be built and became fully operational at the end of 1989.
A submarine oil pipeline links the Omišalj Terminal with the INA Oil Refinery in Rijeka, while the principal line runs to Sisak refinery, 50 km south of Zagreb, where it splits in two trunks: the south one goes to Serbian refineries settled in Novi Sad and in Pancevo (Belgrade), running parallel to the Bosnian border and supplying Brod refinery on the south shoreline of Sava river, and the north one crosses Croatian territories until Gola, lying on the Hungarian border, where it continues until Duna refinery in Százhalombatta and is connected to the southern line of Druzhba pipeline. In Virje, a secondary branch of Adria pipeline turns towards Lendava refinery in Slovenia.

From an upstream point of view, hydrocarbons exploration and production are principally concentrated in three areas: south-east of Zagreb, along the Hungarian border and along the Adriatic Sea. Internal oil and gas production is not sufficient for Croatian energy consumption needs, thus Croatia is heavily dependent on imported oil and gas. According to the Croatian Hydrocarbon Agency, onshore hydrocarbon potential in the Pannonian basin is underexplored.



sources:

Geographical metadata
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- DIVA-GIS metadata: www.diva-gis.org

Fossil fuels metadata and information
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org;
- JANAF pipelines: www.janaf.hr; https://en.wikipedia.org/wiki/Adria_oil_pipeline
- INA infrastructures' information: www.ina.hr
- General information about Croatian energy overview: http://www.geni.org/globalenergy/library/national_energy_grid/croatia/EnergyOverviewofCroatia.shtml

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES

OMISALJ OIL TERMINAL

START-UP DATE	-
OPERATING COMPANY	JANAF
STATUS	OPERATING
TYPE	OIL TERMINAL FOR STORAGE
CAPACITY	-
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT IS THE MEDITERRANEAN ENTRY POINT OF CRUDE OIL IN EASTERN EUROPE, BECAUSE IT IS CONNECTED TO THE ADRIA OIL PIPELINE - OIL REFINERIES IN SISAK (HR), BROD (BIH), NOVI SAD (SRB), PANCEVO (SRB) AND LENOAVA (SLO) ARE FED BY OMISALJ OIL TERMINAL

INA GROUP RIJEKA REFINERY CROATIA

START-UP DATE	-
OPERATING COMPANY	INA Industrija Nafte
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	102'000 barrels/day
SOURCE OF WATER	MEDITERRANEAN SEA
PRINCIPAL FEATURES	- CRUDE OIL IMPORTED VIA OIL PORT IN OMISALJ

INA GROUP SISAK REFINERY CROATIA

START-UP DATE	-
OPERATING COMPANY	INA Industrija Nafte
STATUS OF COMPLEX	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	61'000 barrels/day
SOURCE OF WATER	ODRA RIVER
PRINCIPAL FEATURES	- CONNECTED TO ADRIA OIL PIPELINE - CLOSE TO SOME DOMESTIC SMALL OIL FIELDS

PRINCIPAL POWER PLANS

RIJEKA THERMAL POWER PLANT CROATIA

START-UP DATE	-
OPERATING COMPANY	Hrvatska elektroprivreda (HEP) d.d.
STATUS	OPERATING
TYPE	SUB-CRITICAL STEAM TURBINE
TYPE OF FUEL	HEAVY FUEL OIL
SOURCE OF FUEL	OIL TERMINAL
CAPACITY	320 MW
PRINCIPAL FEATURES	-

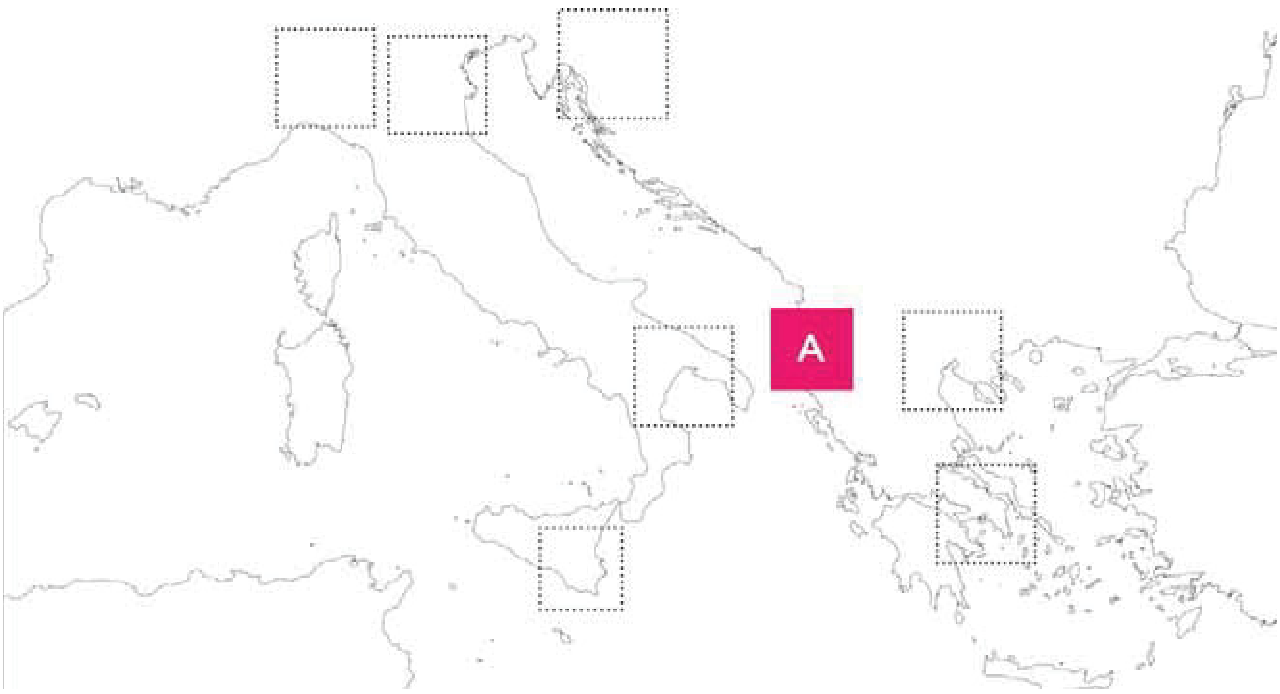
10 km

SISAK THERMAL POWER PLANT CROATIA

START-UP DATE	-
OPERATING COMPANY	Hrvatska elektroprivreda (HEP) d.d.
STATUS	OPERATING
TYPE	SUB-CRITICAL STEAM TURBINE
TYPE OF FUEL	OIL
SOURCE OF FUEL	OIL TERMINAL
CAPACITY	420 MW
PRINCIPAL FEATURES	-

A

Albanian fossil fuel mesh



Albania has a huge underdeveloped heavy-oil potential in its Myzeqe Plain's subsoil, situated in the south-central region of Albania. Two areas have been explored since the 1920s, but never fully-operating: Patos-Marinza, the largest onshore oil field in Europe, 10 km east of the city of Fier, and Kucova, located 30 km east of Patos-Marinza.
Upstream landscapes are very different between the two production areas: on the one hand, in Kucova, we recognize the presence of old and non-operating vertical drilling wells, dislocated in private and public lots, intermingling with dwellings, while, on the other, Patos-Marinza oil fields are characterized by more recent horizontal oil drilling wells, which scatter the agricultural pattern creating a very peculiar pattern. Canadian Bankers Petroleum's investments made that Albanian heavy crude oil production has tripled over the last decade.

Two small and obsolete refineries, in Ballsh and in Fier, are operated by Albanian Refining and Marketing of Oil (ARMO) and have a global refining capacity of 1.5 million tons. An ongoing modernization project aims to restore oil production to the original design capacity and to produce fuel in line with current EU regulations. Due to the small capacity of national downstream infrastructures, most of Albanian oil is exported, while the country imports refined oil by-products for internal consumption.

No international oil pipelines run through Albania at the moment. An ancient crude oil pipeline connected Kucova oil wells to Ballsh refineries and only recently some Canadian investments of Bankers Petroleum have been foreseen to improve the internal capacity of loaded oil in Vlore harbour connecting it with Patos-Marinza oil fields. The region is provided by a railway connection which links Ballsh refinery to Vlore harbour and it represents an exception in the very weak Albanian railway network which principally runs parallel to the coastline and not in inner areas.

Albania is not connected with any European gas grid. The international project of the Trans Adriatic Pipeline (TAP) consists of a 867 kilometre gas pipeline bringing natural gas from Azerbaijan to southern Italian coasts of Apulia, running through Turkey, Northern Greece and Albania, crossing Fier district. TAP would connect for the first time Albania to a European energy network. The construction of TAP started in 2016 and it is foreseen to be operating by 2020. The project of another natural gas pipeline (516 km long), the Ionian Adriatic one, would be connected to the TAP in Fier and, from here, would run through Montenegro, Bosnia and Herzegovina, to Split in Croatia.

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- General information about Albanian downstream infrastructures: https://www.energyglobal.com/downstream/gas-processing/31102012/eastern_european_ refining_402/
- General information about Albanian energy overview: https://www.energy-pedia.com/news/albania
- BANKERS PETROLEUM infrastructures' information: http://www.bankerspetroleum.com/albania/overview; http://www.albpetrol.al/history-of-albanian-oil/
- ARMO infrastructures' information: https://en.wikipedia.org/wiki/ARMO_oil_refiner

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES

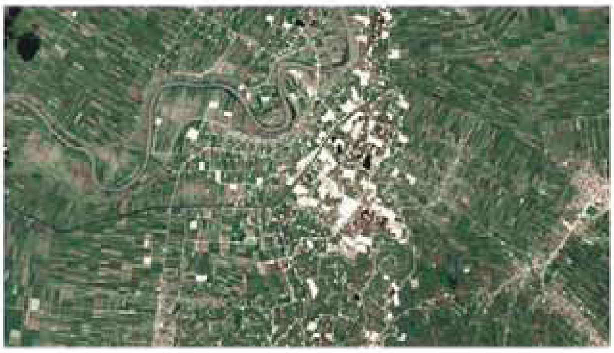
FIER OIL REFINERY

START-UP DATE	-
OPERATING COMPANY	ARMO
STATUS	OBSOLETE
TYPE	CRUDE OIL REFINERY
CAPACITY	10'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT MOSTLY PRODUCES HEAVY FUEL OIL, SOLVENTS, BITUMEN - A MODERNIZATION PROJECT TO RESTORE PRODUCTION TO THE ORIGINAL DESIGN CAPACITY AND TO PRODUCE FUELS IN LINE WITH CURRENT EUROPEAN UNION REGULATIONS IS ONGOING FROM 2012

BALLSH OIL REFINERY

START-UP DATE	-
OPERATING COMPANY	ARMO
STATUS OF COMPLEX	OBSOLETE
TYPE	CRUDE OIL REFINERY
CAPACITY	20'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT MOSTLY PRODUCES VIRGIN NAPHTA, KEROSENE, GASOIL, GASOLINE, PETROLEUM COKE, SULPHUR, FUEL OIL, DILUENTS, LPG, DRY GAS - A MODERNIZATION PROJECT TO RESTORE PRODUCTION TO THE ORIGINAL DESIGN CAPACITY AND TO PRODUCE FUELS IN LINE WITH CURRENT EUROPEAN UNION REGULATIONS IS ONGOING FROM 2012

PRINCIPAL UPSTREAM SITES



PATOS MARINZA OIL FIELDS

START-UP DATE	1928 and 2004
OPERATING COMPANY	BANKERS PETROLEUM
STATUS OF COMPLEX	OPERATING
TYPE	HEAVY OIL
CAPACITY	12'000 barrels/day
PRINCIPAL FEATURES	- IT IS THE BIGGEST ONSHORE OIL FIELD IN EUROPE

PRINCIPAL POWER PLANTS

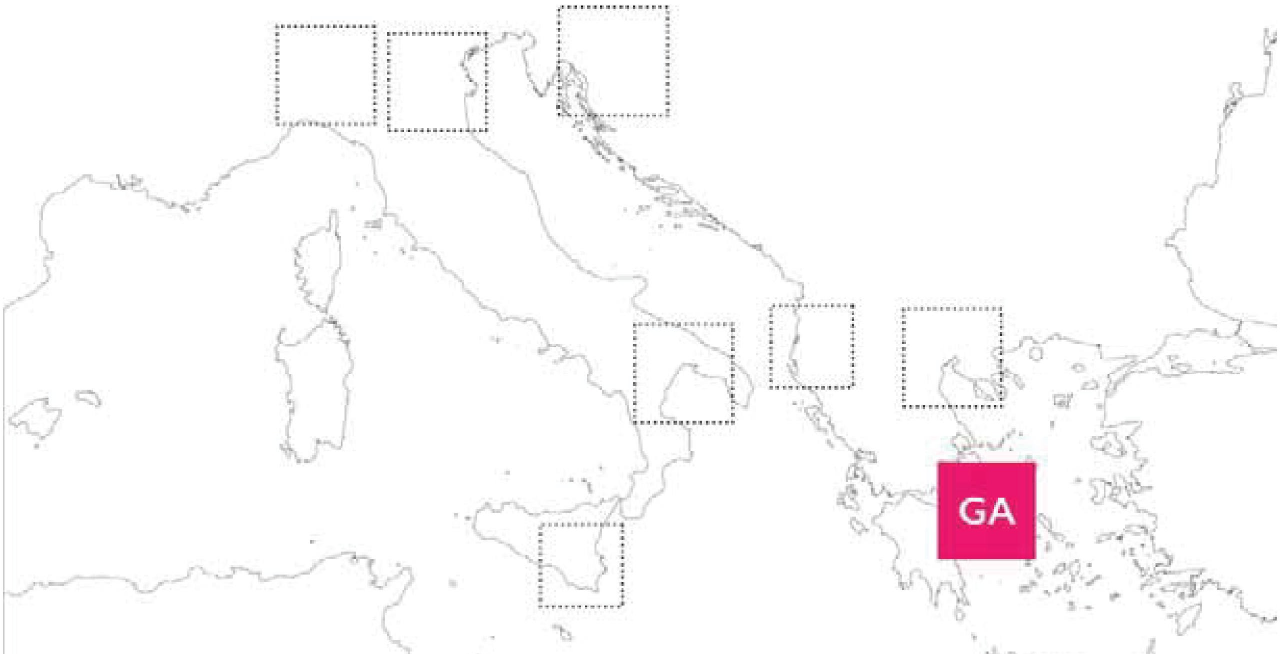
FIER POWER PLANT

START-UP DATE	-
OPERATING COMPANY	-
STATUS	DISMISSED
TYPE	THERMAL POWER PLANT
TYPE OF FUEL	SUB-BITUMINOUS COAL
CAPACITY	186 MW
PRINCIPAL FEATURES	- IT WAS DECOMMISSIONED IN 2007

10 km

GA

Greek Attic fossil fuel mesh

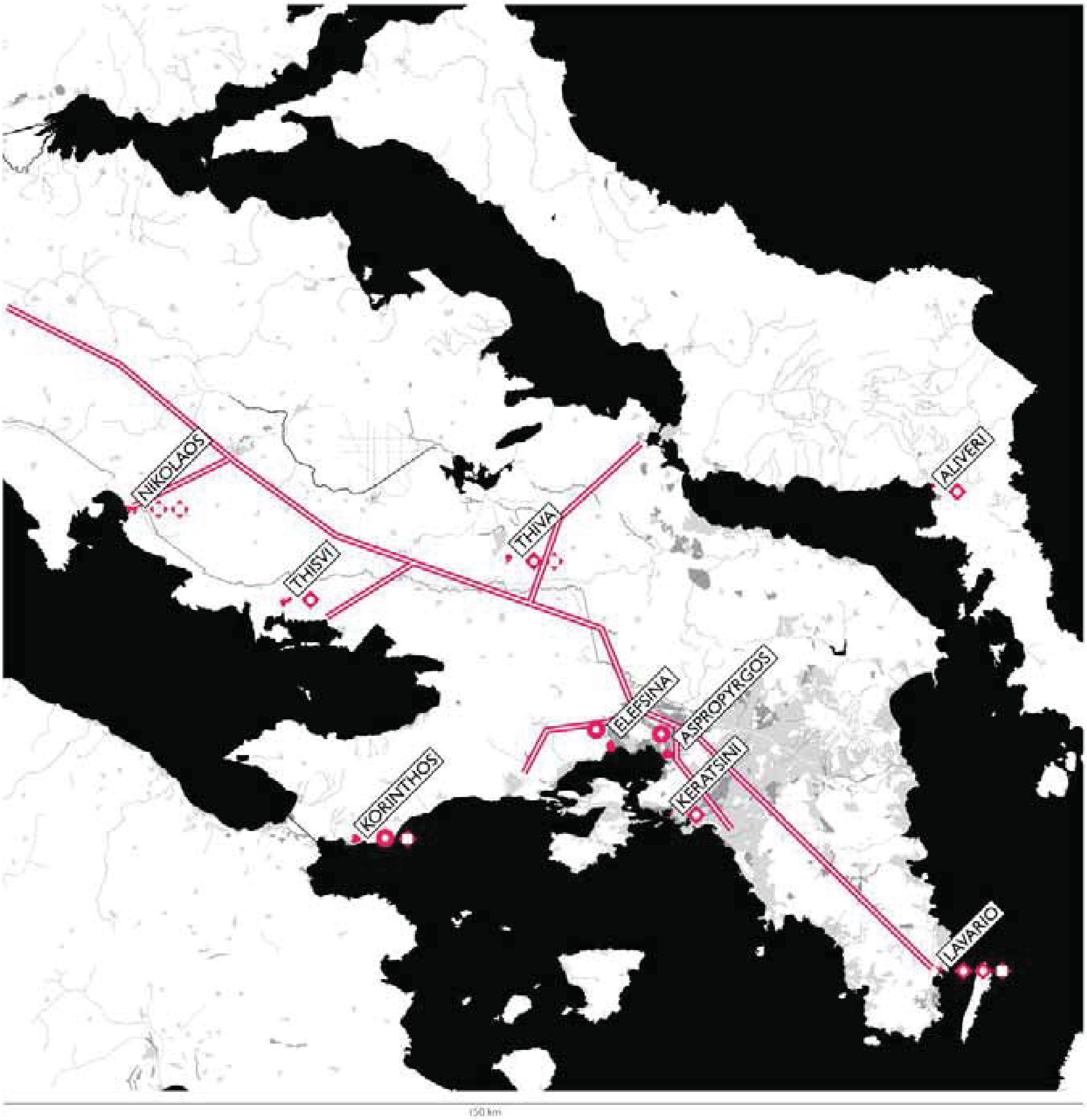


Greek energy consumption is still highly dependent on imported fossil fuel. Oil and gas internal production is minimal, thus Greece is investing in oil and gas exploration to try to reduce its dependence on imported fossil fuel.

Three main refineries are settled in the Attic region: two of them in the proximity of Athens (Aspropyrgos and Elefsina ones), operated by Hellenic Petroleum, and one in the outskirts of Corinth, owned by Motor Oil Hellas. Their coastal situations guarantee a competitive advantage for an easy accessibility of oil tankers.

Aspropyrgos and Elefsina refineries are connected by an oil pipeline which continues until Thessaloniki refinery, in West Macedonia, and then to the unique oil refinery in FYROM in Skopje.

In Agios Nikolaos, a CCGT power plant which functions in close synergy with the local industrial district takes place: the steam produced is supplied to the aluminium industry for productive uses.
In Lavario, in the southern part of Attic region, three power plants, mostly powered by oil, occupy an important coastal area.



- OIL REFINERY
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Fossil fuels metadata and information
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org
- General information about Greek pipelines: http://www.wikiwand.com/en/Greece-Italy_relations
- General information about Greek downstream infrastrcutures:
https://www.energyglobal.com/downstream/gas-processing/31102012/eastern_european_refining_402/
https://en.wikipedia.org/wiki/Aspropyrgos_Refinery
- MOH infrastructures' information: http://www.moh.gr/Home.aspx?a_id=256
- HELPE infrastructures' information: http://www.helpe.gr/en/
- MYTILINEOS and DEI power plants' information: http://www.mytilineos.gr; https://www.dei.gr/en

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES

MOTOR OIL HELLAS CORINTH REFINERY

START-UP DATE	1970
OPERATING COMPANY	MOTOR OIL HELLAS
STATUS	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	380'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	-

HELLENIC PETROLEUM ELEFSINA REFINERY

START-UP DATE	-
OPERATING COMPANY	HELLENIC PETROLEUM
STATUS	OPERATING
TYPE	CRUDE OIL REFINERY
CAPACITY	100'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT IS CONNECTED BY A PIPELINE WITH THESSALONIKI AND ASPROPYRGOS REFINERIES

HELLENIC PETROLEUM ASPROPYRGOS REFINERY

START-UP DATE	-
OPERATING COMPANY	HELLENIC PETROLEUM
STATUS	OPERATING
TYPE	HEAVY OIL REFINERY
CAPACITY	135'000 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT IS CONNECTED BY A PIPELINE WITH THESSALONIKI AND ELEFSINA REFINERIES

PRINCIPAL POWER PLANTS

DISTOMO CCGT POWER PLANT IN AGIOS NIKOLAOS

START-UP DATE	-
OPERATING COMPANY	MYTILINEOS GROUP
STATUS	OPERATING
TYPE	POWER AND HEATCOMBINED CYCLE GAS TURBINE
TYPE OF FUEL	NATURAL GAS
SOURCE OF FUEL	-
CAPACITY	320 MW
PRINCIPAL FEATURES	- POWER PLANT USED FOR COGENERATION - STEAM SUPPLIED TO ALUMINIUM INDUSTRY - ELECTRICITY IS NORMALLY EXPORTED TO THE NATIONAL GRID WITH A BACK-UP ROLE

10 km

LAVARIO MEGALO CCGT POWER PLANT

START-UP DATE	-
OPERATING COMPANY	PUBLIC POWER CORP (DEH)
STATUS	OPERATING
TYPE	COMBINED CYCLE GAS TURBINE
TYPE OF FUEL	NATURAL GAS + LIGHT FUEL OIL
SOURCE OF FUEL	NATIONAL GAS GRID
CAPACITY	570 MW
PRINCIPAL FEATURES	-

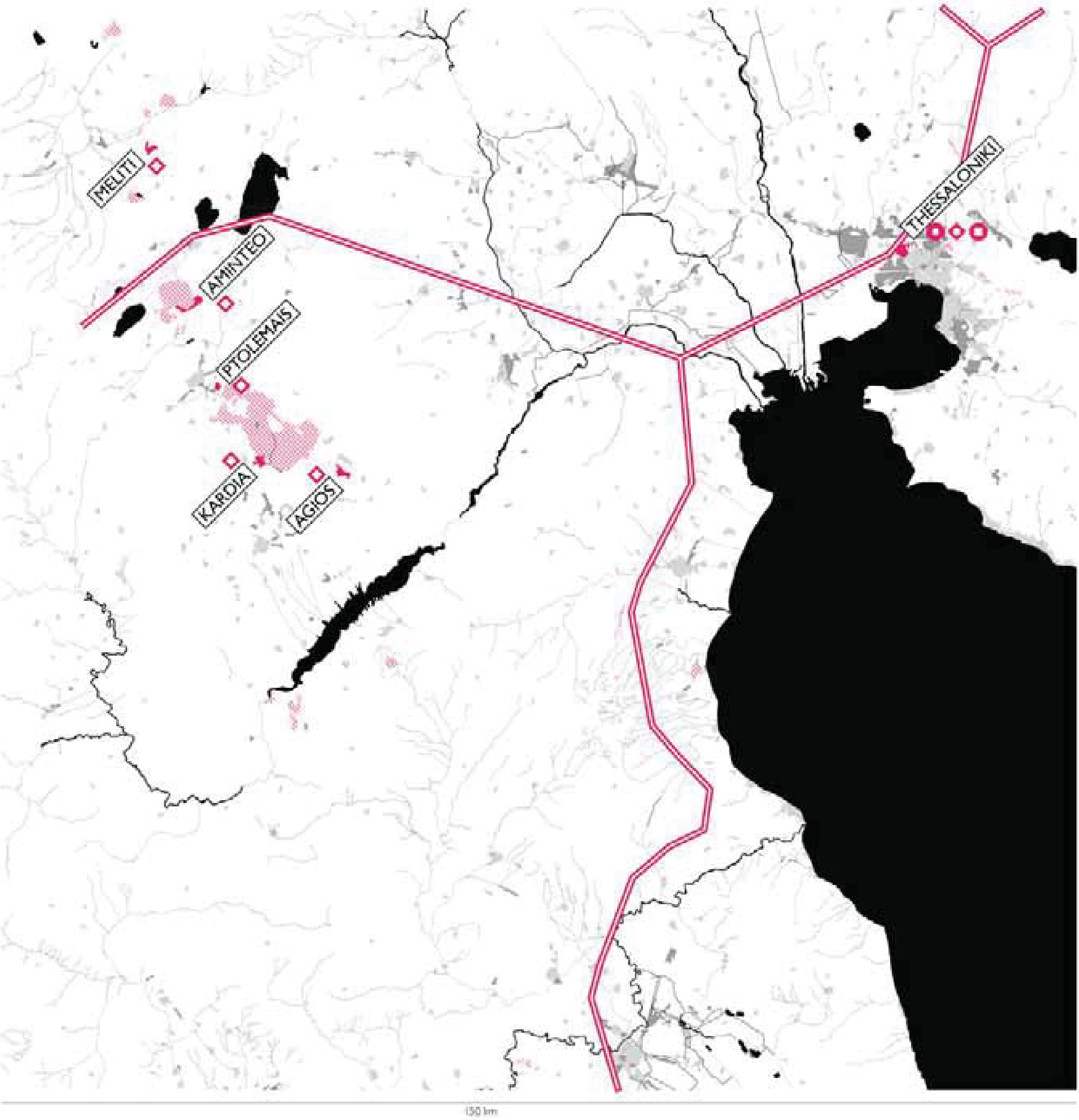
GT

Greek Thessaloniki fossil fuels mesh

The Thessaloniki refinery, operated by Hellenic Petroleum, is connected through an oil pipeline to the two ones in the Attic region (Elefsina and Aspropyrgos) and to the sole FYROM refinery in Skopje.

What is outstanding in West Macedonia region is the huge presence of lignite mines in Ptolemaida area which still power several lignite-fired power plants. In fact, the Greek energy system is still relying to a large extent on lignite power plants. Lignite is the only domestic energy source, even if it is not sufficient to guarantee an energetic independence. Indeed, it is estimated that Greece, in 2013, had an energy dependency rate of 62.1%, considerably higher to EU-28 average which is around 53%. Furthermore, Greece imports 100% of the natural gas and 98% of the oil it consumes. Lignite has a very low calorific value, but highly negative externalities, especially regarding public health. Even if several factors (EU climate policies, the Industrial Emissions Directive, the drop of renewable energies' costs) are challenging the dominant role of lignite in the energetic panorama, which results to be not profitable at all in cost-efficiency terms, it seems that Greek public authorities want to continue investing in lignite infrastructure, extending the operation of old lignite-fires power plants and building new ones .

The Turkey–Greece gas pipeline, 296 km long and completed in 2007, begins in Karacabey in Turkey and runs to Komotini in Greece, 200 km east of Thessaloniki. The Greece–Italy section, part of the TAP project and connected to the Turkey-Greece one, has to be implemented yet and will cross Thessaloniki province.



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- HELPE infrastructures' information: http://www.helpe.gr/en/
- DEI power plants' information: https://www.dei.gr/en

Ortophotos
- Google Earth

PRINCIPAL DOWNSTREAM SITES

HELLENIC PETROLEUM THESSALONIKI REFINERY

START-UP DATE	-
OPERATING COMPANY	HELLENIC PETROLEUM
STATUS	OPERATING
TYPE	CRUDE OIL HYDROSKIMMING REFINERY
DESIGN CAPACITY	66'500 barrels/day
SOURCE OF WATER	-
PRINCIPAL FEATURES	- IT IS CONNECTED TO THE SOLE REFINERY IN F IN SKOPJE, THROUGH A PIPELINE - IT OPERATES IN CONJUNCTION WITH THE ASPROPYRGOS AND ELEFSINA REFINERIES AS AN INTEGRATED PRODUCTION UNIT THROUGH A PIPELINE - PETROCHEMICAL PRODUCTION UNITS ARE IN OPERATION IN THE RFINERY COMPLEX

PRINCIPAL POWER PLANTS

AMINTEO COAL POWER PLANT

START-UP DATE	1987
OPERATING COMPANY	PUBLIC POWER CORP (DEH)
STATUS	OPERATING
TYPE	SUB-CRITICAL THERMAL
TYPE OF FUEL	COAL LIGNITE
SOURCE OF FUEL	BY CONVEYOR FROM ADJACENT AMYNTAIO LIG MINE
DESIGN CAPACITY	600 MW
PRINCIPAL FEATURES	-

PTOLEMAIS COAL POWER PLANT

START-UP DATE	1959
OPERATING COMPANY	PUBLIC POWER CORP (DEH)
STATUS	OPERATING
TYPE	SUB-CRITICAL THERMAL
TYPE OF FUEL	COAL LIGNITE
SOURCE OF FUEL	ADJACENT PTOLEMAIS-AMYNTAIO LIGNITE BASI
DESIGN CAPACITY	550 MW
PRINCIPAL FEATURES	-

KARDIA COAL POWER PLANT

START-UP DATE	1981
OPERATING COMPANY	PUBLIC POWER CORP (DEH)
STATUS	OPERATING
TYPE	SUB-CRITICAL THERMAL
TYPE OF FUEL	COAL LIGNITE
SOURCE OF FUEL	ADJACENT PTOLEMAIS-AMYNTAIO LIGNITE BASI
DESIGN CAPACITY	1'250 MW
PRINCIPAL FEATURES	-

10 km

AGHIOS DIMITROS COAL POWER PLANT

START-UP DATE	1984
OPERATING COMPANY	PUBLIC POWER CORP (DEH)
STATUS	OPERATING
TYPE	SUB-CRITICAL THERMAL
TYPE OF FUEL	COAL LIGNITE
SOURCE OF FUEL	BY CONVEYOR FROM WESTERN MACEDONIA LI MINES
DESIGN CAPACITY	1'595 MW
PRINCIPAL FEATURES	-

A dichotomous proximity

infrastructure

As a consequence of classical modernity thinking, *dichotomies* ruled and rigidly organized the landscapes of the two industrial revolutions: *city* vs *countryside*, *infrastructure* vs *landscape, industry* vs *nature*. The Occidental anthopocentric consciousness typical of the industrialization era (think at the notion of *Übermensch*[1] supported by Nietzsche at the end of the XIX century) reduced the role of the *host nature* to a mere support where to meet the economic and well-being needs of Western human beings, here and now:

- *countryside* should have fed an increasingly growing urban population;
- *landscape* should have represented a simple support, sometimes even awkward, to connect anthropic activities through fast and more profitable, but even more and more impermeable and not crossable, transport axes;
- *nature* should have accepted and remedied to industrial activities' waste.

Doubtless, the cultural context and ideological framework during which most of fossil fuel industrial sites have been settled was less receptive to environmental issues than we currently are. Thus, refineries, petrochemical infrastructure and power plants were often located in proximity of water courses for functional reasons, but it results that they affected very fragile and protected natural environments (i.e. Natura 2000 sites[2] or Emerald areas[3]), or even important archaeological or cultural heritage sites.

The GIS cartographical analysis of our 8 territorial case studies seems to confirm our assumption, highlighting a modern *dichotomous proximity* which directly transforms dangers into effects. We identified two simple types of relationships between fossil fuel existing industrial sites and protected areas:

- *intersections* contemplate a physical presence of polluting downstream sites or thermal power plants within Natura 2000 protected areas;
- *proximities* consider a possible delicate relationship between fossil fuel industry sites and territories which are not necessarily considered protected areas, but which play a fundamental role in local economic structures.

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1 *Übermensch* is a concept in the philosophy of Friedrich Nietzsche appeared for the first time in 1883 in his *Thus spoke Zarathustra*. The Übermensch abandons false ethical and social values and wants to prevail himself as an individual, placing his personal values before common morals. The purpose of the Übermensch is to obtain the immanent happiness through creative ability.

2 Natura2000 sites is a network of nature protection areas in the European Union territory. It consists of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) designated respectively under the Habitats Directive and Birds Directive. The network includes both terrestrial and marine sites. Natura 2000 protects 27,312 sites with terrestrial area 787,606 km^2 (around 18% of land of the EU countries) and marine area 360,350 km^2 in 2017 (see ec.europa.eu/environment/nature/natura2000)..

3 Emerald areas is a network of nature protection areas to conserve wild flora and fauna and their natural habitats of Europe, which was launched in 1998 by the Council of Europe as part of its work under the Convention on the Conservation of European Wildlife and Natural Habitats or Bern Convention that came into force on 1 June 1982. The Emerald Network is based on the same principles as Natura 2000, and represents its de facto extension to non-EU countries. (for example Albania).

North-western Po Valley case study

Trecate oil refinery is situated on the banks of Ticino river, in the very middle of the Ticino valley natural park, which, since 2002, is considered a *Biosphere reserve*[4] part of the *Man and Biosphere program* by UNESCO. Sannazzaro de Burgondi oil refining is clumped between two protected areas: *Lomellina*, which is particularly renowned for its rice paddies, cultivated here since the XVI century and the *Po and Orba river park,* which combines the landscape of the Po alluvial valley with the aquitrinous landscape of rice paddies.

North-eastern Po Valley case study

Two are the very critical situations which stand out from the analysis of the GIS cartography. In the eastern part of the Polesine region (Veneto), Enel Polesine Camerini thermal power plant is located in the middle of the *ecosystem of the Po Delta*, a delicate brackish below the sea level landscape which combines wetlands, dunes, mussels farms with a complicated drainage system started during the XVII century. More to the north, Porto Marghera fossil fuel activities are directly overlooking *Venice lagoon*, in continuity with natural sandbanks and artificial territories obtained through the dredging material of the industrial harbour channels until 1969 (*casse di colmata*) and which have now been redeployed by nature.

Albanian case study

In Albania, even if downstream oil panorama is less developed than in Western Europe, it results to be a highly hazardous environmental risk because of the lack of environmental directives. The Gjanica river, a tributary of Seman river, is the most polluted river in Albania because of the petroleum waste in Patos-Marinza upstream sites and in Ballsh refinery, so deeply affecting the quality of the agricultural production of Myzeqe Plain, which is not a protected area belonging to Emerald network, but it is considered the most important agricultural region in Albania.

Sicilian case study

Refineries and petrochemical sites completely saturated the sea access from the Augusta bay and have been settled on archaelogical Hellenistic sites, heavily compromising the ever-lost heritage of Thapsos and Megara Hyblaea.

4 Biosphere reserves are areas comprising terrestrial, marine and coastal ecosystems. Each reserve promotes solutions reconciling the conservation of biodiversity with its sustainable use. (see http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves)

Environmental risks are not only related to the huge damages occurred during the operational phase of those industrial sites, but they remain latent, and probably even more dangerous, after their dismantling if not handled in time and in the correct manner. Land reclamation is something that is too often omitted by private owners who stop site production, so leaving a soil pollution which mostly worsen the situation further deeply.
Furthermore, future horizons for downstream sector on Western Adrion coasts don't seem to envisage a different trend in next decades: we can imagine that current downstream oil sector crisis in Europe, together with an increasing environmental cultural conscience, which is slowly leading to an energetic infrastructural conversion towards renewable energies, are going to leave further huge dismissed refineries and petrochemical sites on our territories.

The proximity between oil infrastructure and fragile environements represents a threat for territories' health because of that dichotomic approach which wanted to categorize and fence all the territorial components in a monofunctional land use definition: nature means entertainment, industry stands for production and routes refers to mobility. It resulted that the necessity to separately name the single components of the territorial reality, extrapolating them from the more complex context, led to an excessive fragmentation of responsabilities towards technical competences, which look at the solution in their specific field, but lose that general overview that can keep parts together in a coherent way.
In the light of a wider reconversion of oil infrastructure towards the territorial restructuring of the third industrial revolution, the already discussed dichotomous proximity can turn in a real territorial opportunity: it would be enough to accept that contemporary reality is complex and we cannot reduce it to a single word to describe it, but it consists of a mix of nuances which includes a concept and its apparent opposite, coexisting and feeding their existence each other.
The definition of *Green infrastructure* provided by the EU Commission[5] could help us to disambiguate the field in which we believe oil infrastructure should be rethought and redesigned in order to respond to new socio-ecological purposes:

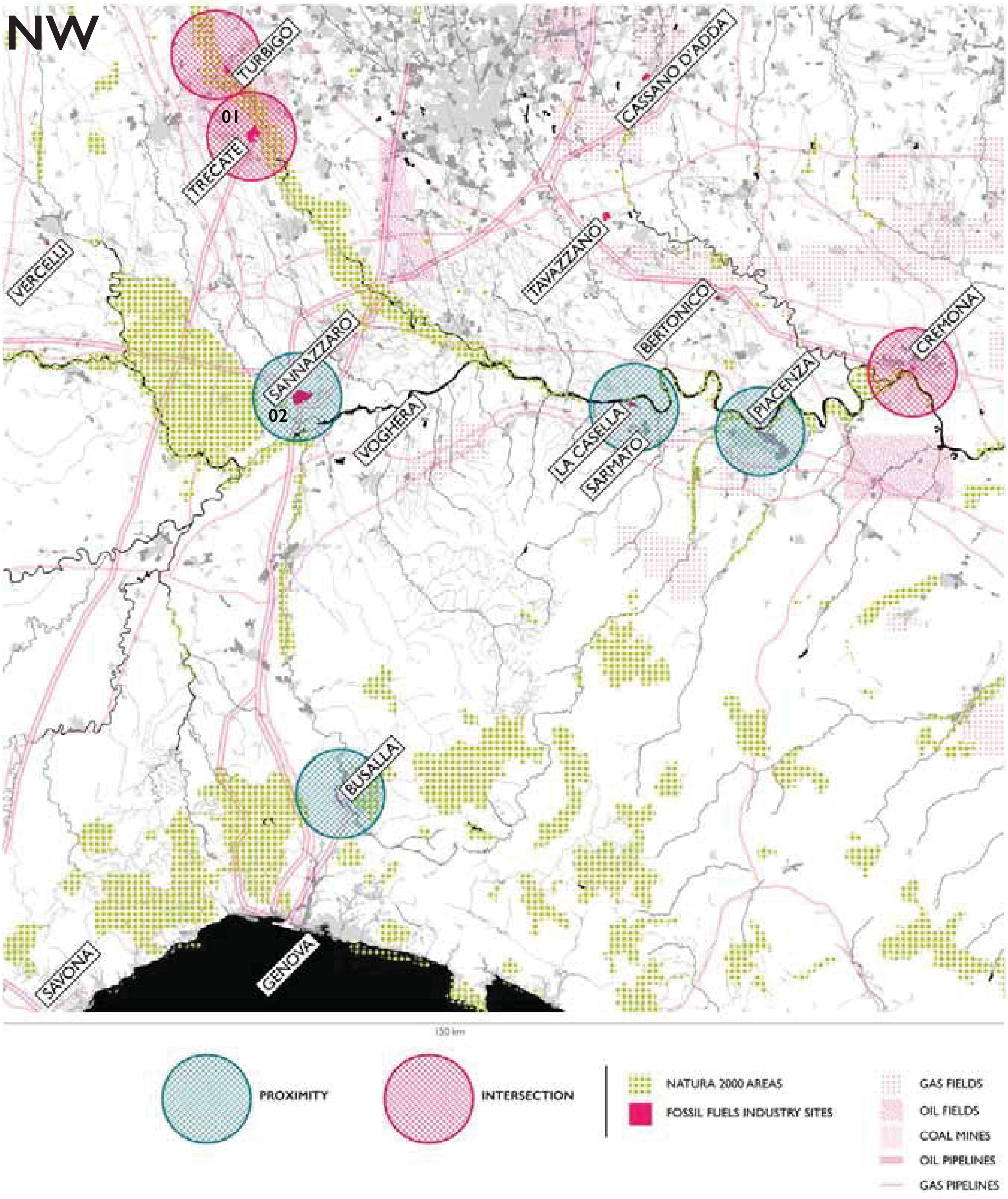
> *Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. It supports a green economy, creates job opportunities and enhances biodiversity. The Natura 2000 network constitutes the backbone of the EU green infrastructure. Green infrastructure planning is a successfully tested tool to provide environmental, economic and social benefits through natural solutions and help reduce dependence on 'grey' infrastructure that is often more expensive to build and maintain.*

5 see http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

Going through the technical working documents on Green Infrastructure provided by the European Commission (2013), we would like to focus on Green Infrastructure benefits' table so as to underline the real potential we can glimpse proposing to shift the notion of infrastructure. It is important to notice that energy realm is included among possible benefits in investing in green infrastructure concept, so challenging the traditional separation of energy production infrastructure from natural areas:

BENEFITS GROUP	SPECIFIC GREEN INFRASTRUCTURE BENEFITS
ENHANCED EFFICIENCY OF NATURAL RESOURCES	MAINTENANCE OF SOIL FERTILITY BIOLOGICAL CONTROL POLLINATION STORAGE OF FRESHWATER RESOURCES
CLIMATE CHANGE MITIGATION AND ADAPTATION	CARBON STORAGE AND SEQUESTRATION TEMPERATURE CONTROL STORM DAMAGE CONTROL
DISASTER PREVENTION	EROSION CONTROL REDUCTION OF THE RISK OF FOREST FIRES FLOOD HAZARD REDUCTION
WATER MANAGEMENT	REGULATION OF WATER FLOWS WATER PURIFICATION WATER PROVISIONING
LAND AND SOIL MANAGEMENT	REDUCTION OF SOIL EROSION MAINTAINING SOIL'S ORGANIC MATTER INCREASING SOIL FERTILITY AND PRODUCTIVITY MITIGATING LAND TAKE AND SOIL SEALING IMPROVING LAND QUALITY AND ATTRACTIVENESS HIGHER PROPOERTY VALUES
CONSERVATION BENEFITS	EXISTENCE VALUE OF HABITAT, SPECIES, DIVERSITY BEQUEST AND ALTRUIST VALUE OF HABITAT
AGRICULTURE AND FORESTRY	MULTIFUNCTIONAL RESILIENT AGRICULTURE ENHANCING POLLINATION ENHANCING PEST CONTROL
LOW-CARBON TRANSPORT AND ENERGY	BETTER INTEGRATED TRANSPORT SOLUTIONS INNOVATIVE ENERGY SOLUTIONS
INVESTMENT AND EMPLOYMENT	BETTER IMAGE MORE INVESTMENT MORE EMPLYMENT LABOUR PRODUCTIVITY
HEALTH AND WELL-BEING	AIR QUALITY AND NOISE REGULATION ACCESSIBILITY FOR AMENITY BETTER HEALTH AND SOCIAL CONDITIONS
TOURISM AND RECREATION	DESTINATIONS MADE MORE ATTRACTIVE CAPACITY OF RECREATIONAL OPPORTUNITIES
EDUCATION	TEACHING RESOURCE AND NATURAL LABORATORY
RESILIENCE	RESILIENCE OF ECOSYSTEM SERVICES

Table 1 Benefits and functions of Green Infrastructure (source: European Commission, 2013)



sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

INTERSECTION #01

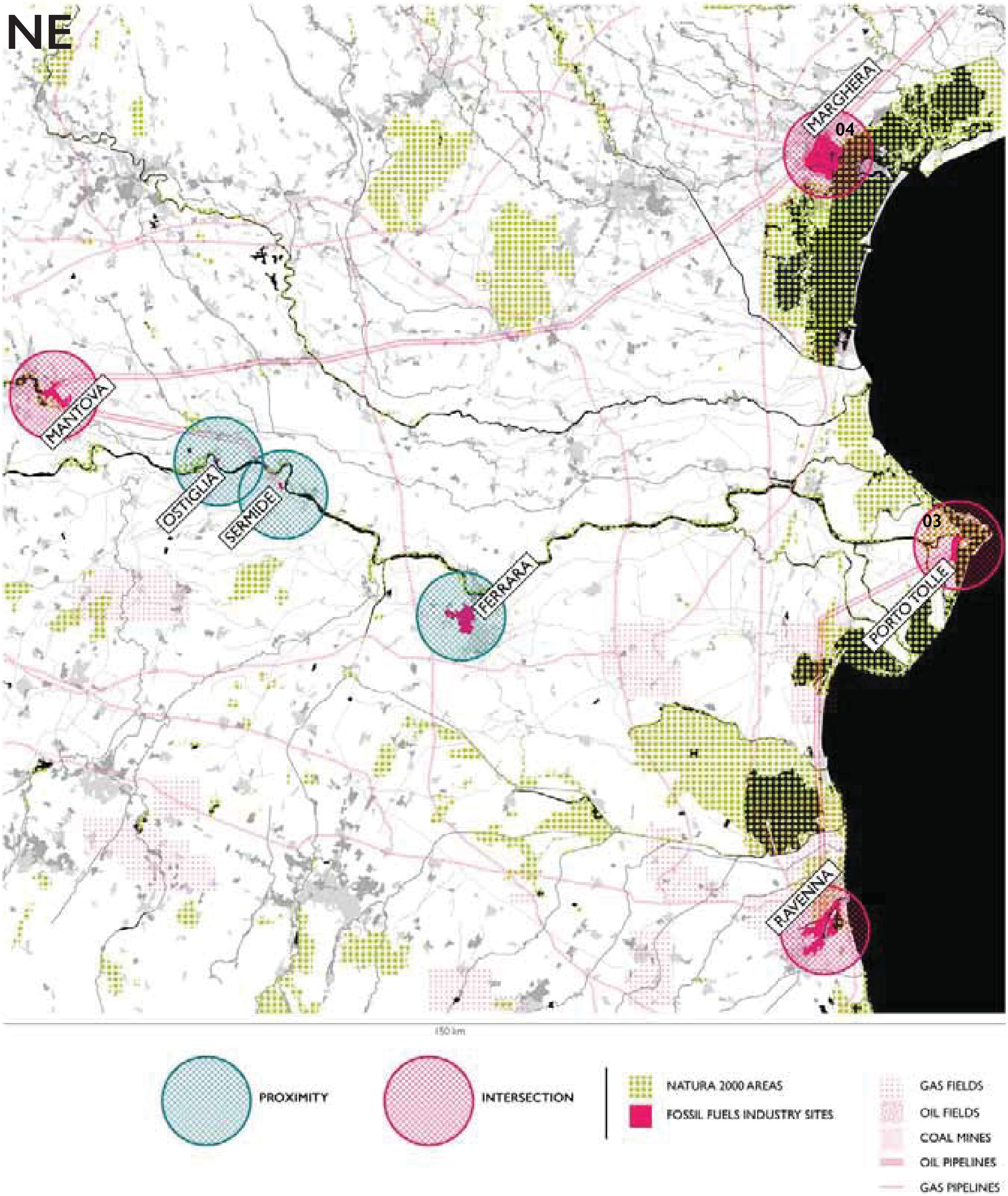
Fig. 48 Exxon Mobil-ERG Trecate oil refinery (source: www.antonini-foto.it)

Fig. 49 Ticino Valley natural park (source: Alessandro Vecchi)

PROXIMITY #02

Fig. 50 ENI Sannazzaro de Burgondi oil refinery (source:www.ilgiorno.it/pavia)

Fig. 51 Lomellina rice fields (source: https://vivoinlomellina.wordpress.com)



sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

INTERSECTION #03

Fig. 52 ENEL Polesine Camerini power plant (source: http://www.bioecogeo.com/33206-2/)

Fig. 53 Veneto Po delta park (source: https://www.zainoo.com/it/guida-italia/veneto/rovigo/delta-del-po)

INTERSECTION #04

Fig. 54 Porto Marghera petrochemical site (source: www.mosevenezia.eu)

Fig. 55 Venice lagoon (source: www.mosevenezia.eu)

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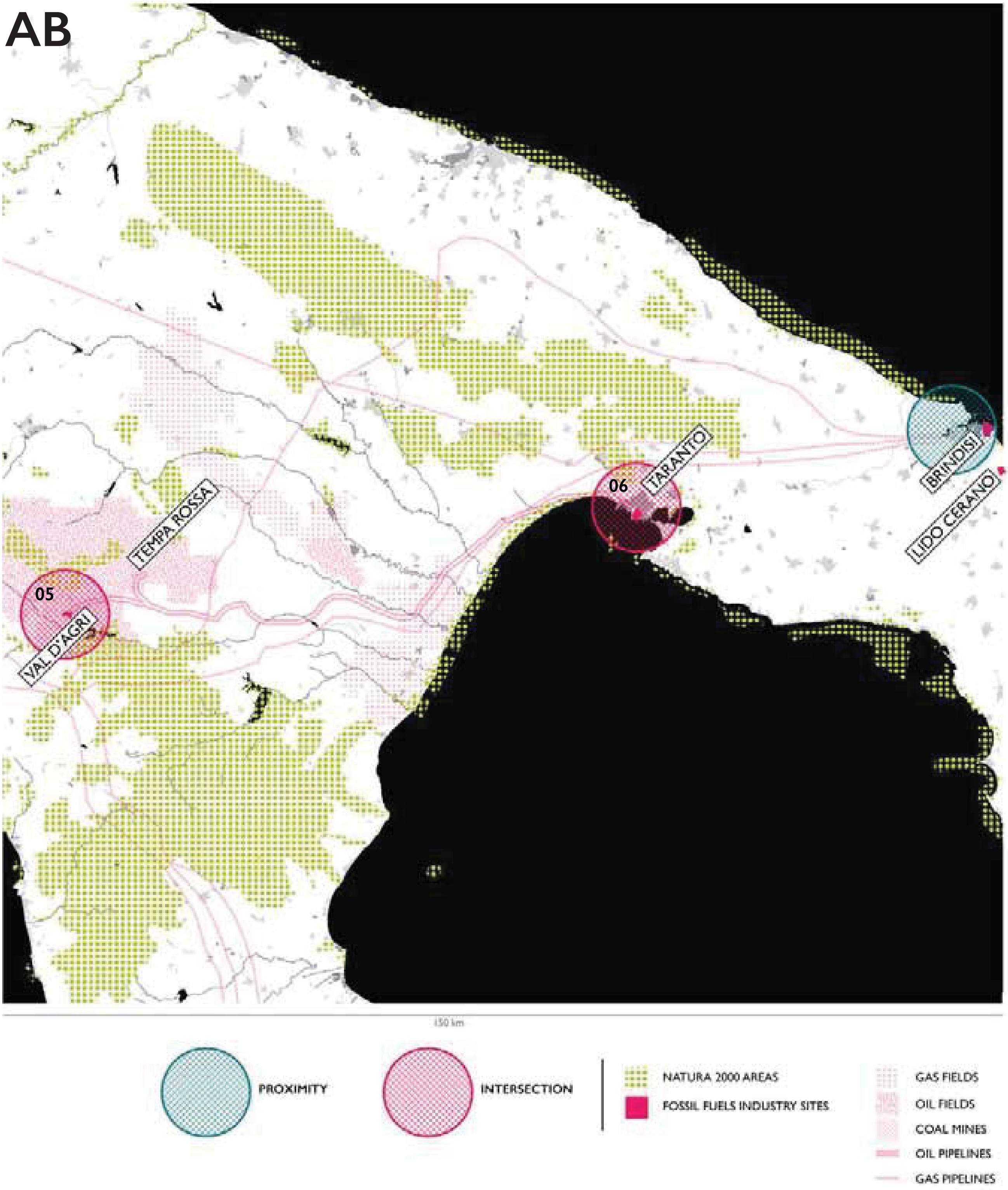

sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

INTERSECTION #05

Fig. 56 Oil well in Val d'Agri (source: ENI website)

Fig. 57 Val d'Agri (source: ENI website)

INTERSECTION #06

Fig. 58 ENI Taranto oil refinery (source: http://bari.repubblica.it/cronaca)

Fig. 59 La Vela Swamp, taranto (source: Lilia Candida - WWF Taranto)

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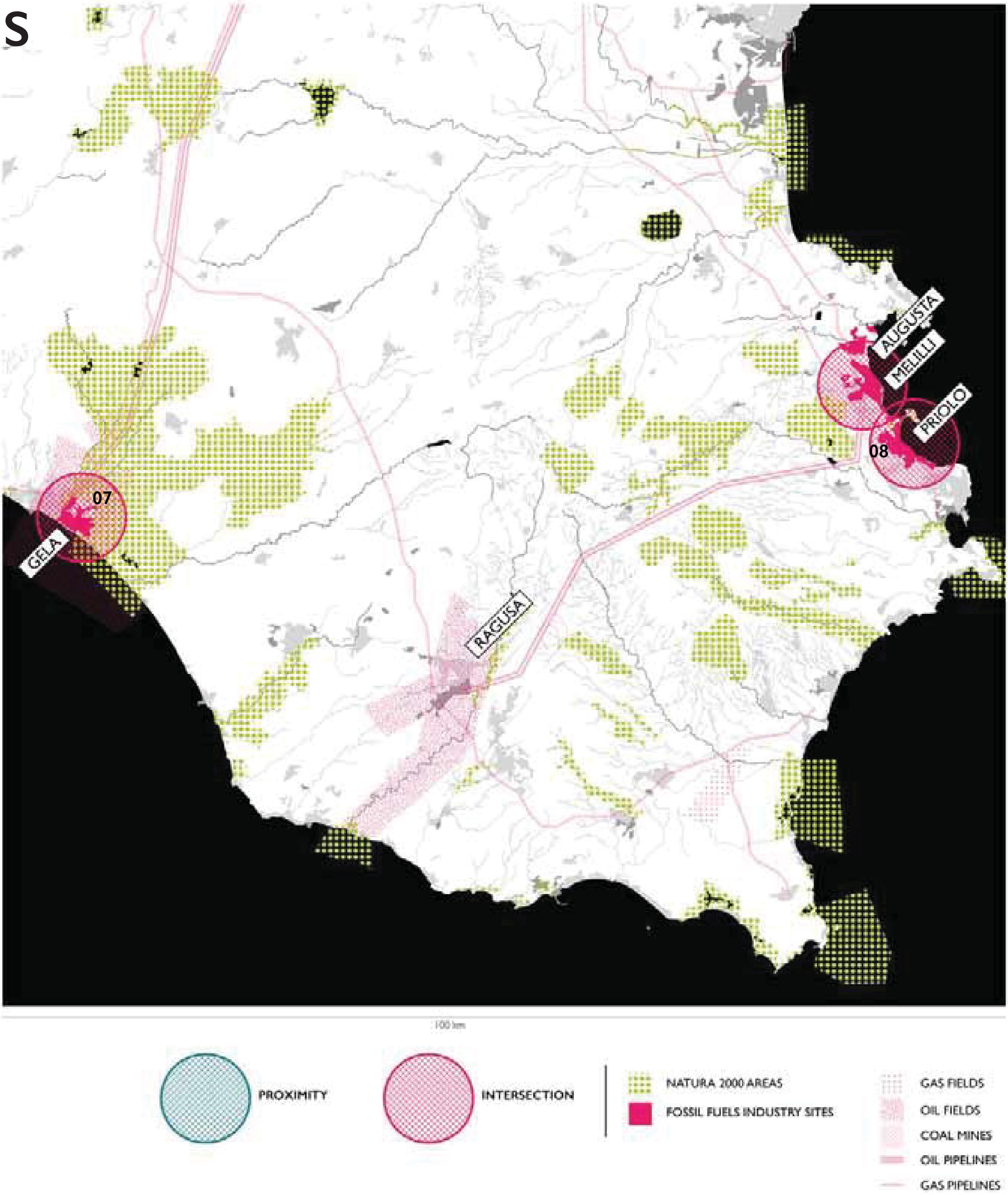


sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

INTERSECTION #07

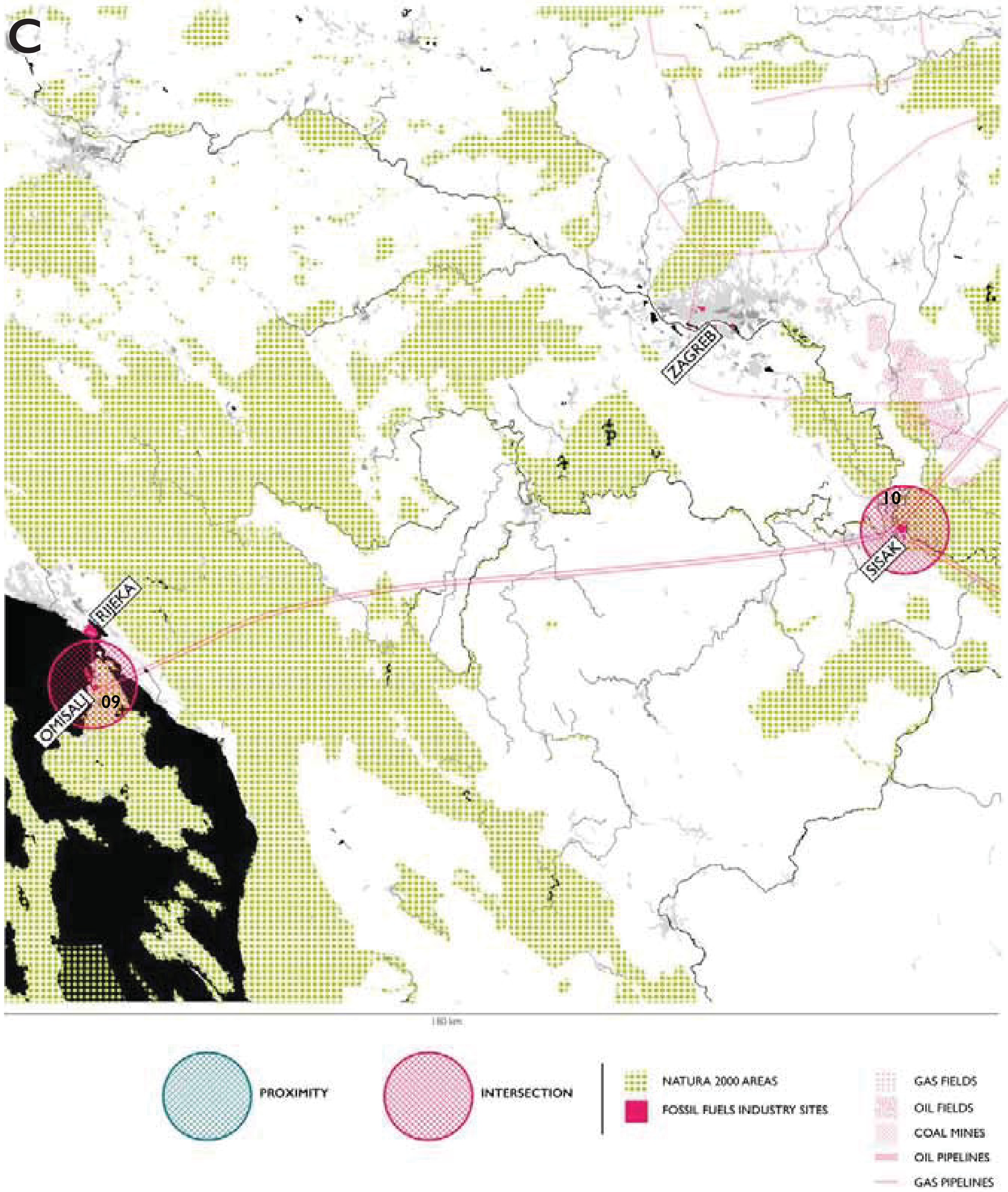
Fig. 60 ENI Gela refinery (source: https://commons.wikimedia.org/wiki/File:Gela_zona_industriale_dall%27alto.JPG)

Fig. 61 Sughereta di Niscemi nature reserve (source: https://commons.wikimedia.org/wiki/File:Sughereta_Niscemi06.jpg)

INTERSECTION #08

Fig. 62 Priolo Gargallo refinery (source: http://siracusa.gds.it)

Fig. 63 Megara Hyblea archaeological site (source: Lamberto Rubino)



sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

INTERSECTION #09

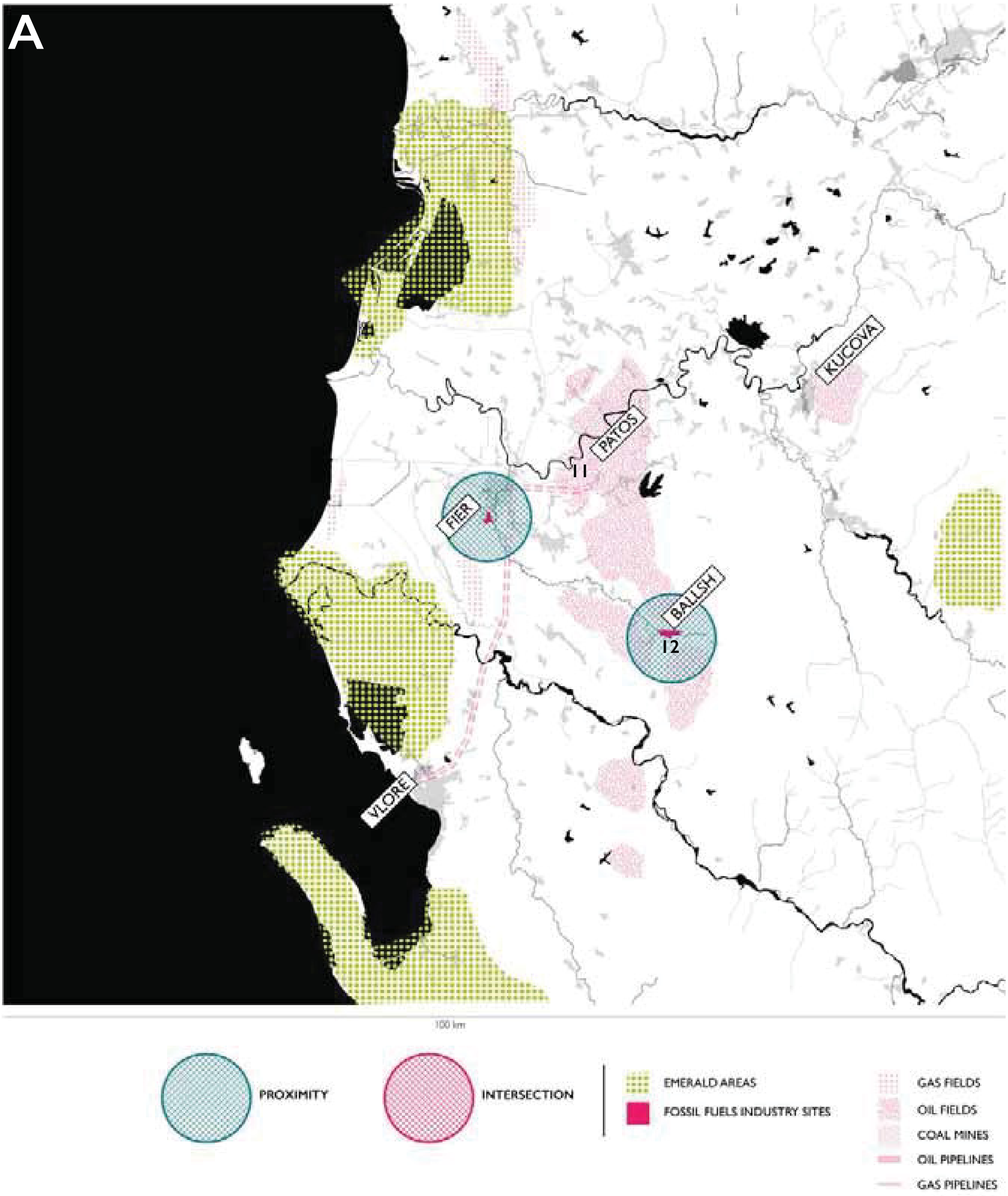
Fig. 64 MOL Rijeka oil refinery (source: https://commons.wikimedia.org/wiki/File:Kraljevica_2010_0728_02.JPG)

Fig. 65 Krk island (source: https://commons.wikimedia.org/wiki/File:Stara_Baška.jpg)

INTERSECTION #10

Fig. 66 MOL Sisak oil refinery (source: www.tportal.hr)

Fig. 67 Odransko Polje (source: Goran Safarek www.balkanrivers.net)



sources: **Geographical metadata**

- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Emerald network: ALIAJ, B. et al. (2014) 'Albania 2030'. A National Spatial Development Vision. [Online] 2014
- DIVA-GIS metadata: www.diva-gis.org

PROXIMITY #11


Fig. 68 Patos-Marinza oil wells (source: Eltjon Valle)

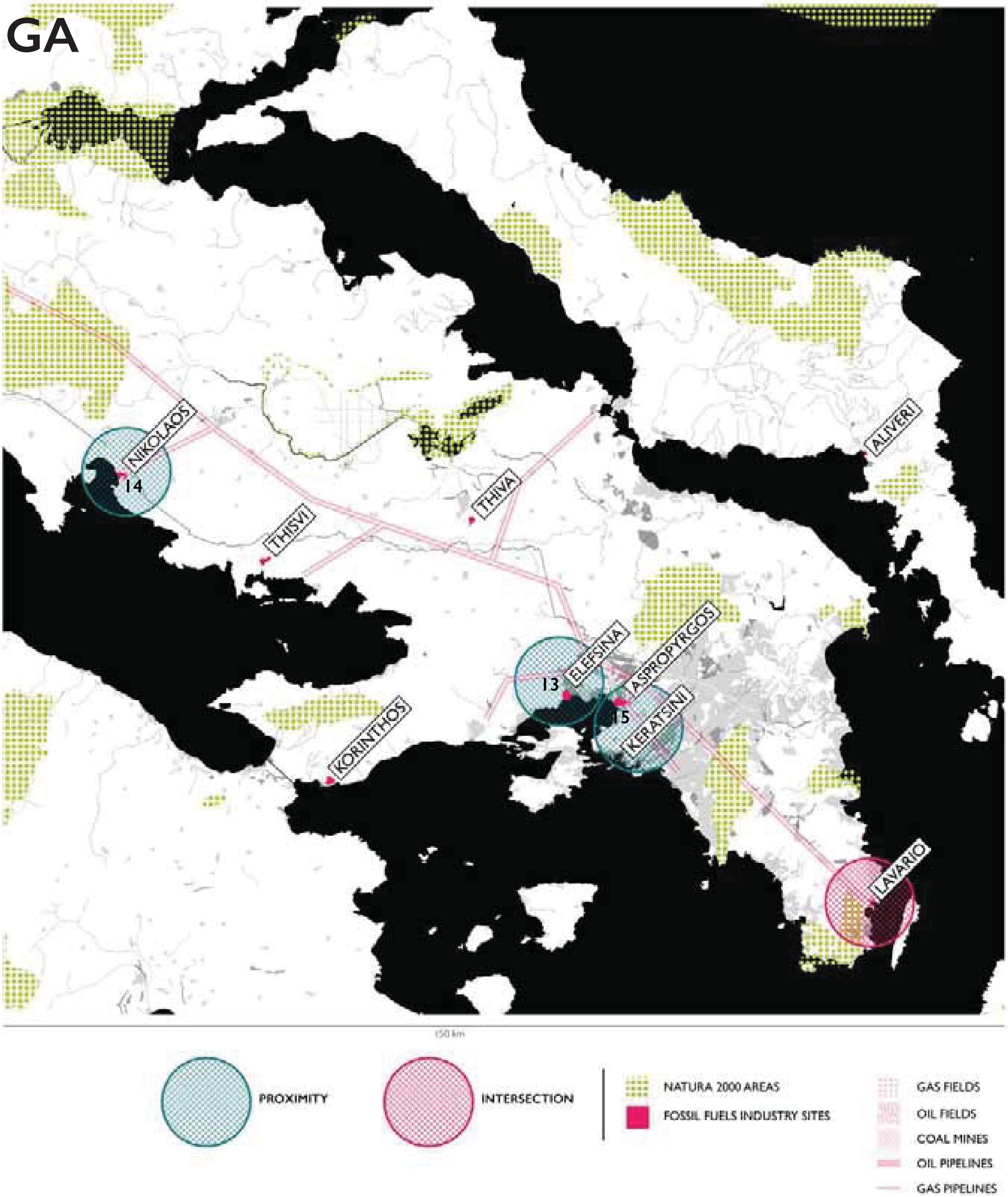

Fig. 69 Seman river (source: Enrico Porfido)

PROXIMITY #12


Fig. 70 Ballsh refinery (source: UNEP)


Fig. 71 Fier region agricultural fields (source: Alessandro Pracucci)

GA



sources: **Geographical metadata**

- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

PROXIMITY #13

Fig. 72 Elefsina refinery (source: https://zarifopoulos.com/portfolio/elpe/?lang=en)

Fig. 73 Elefsina Gulf (source: http://www.panoramio.com/photo/88755795)

PROXIMITY #14

Fig. 74 Agios Nikolaos power plant and aluminium industry (source: http://www.stager.gr/index.php/gr/works)

PROXIMITY #15

Fig. 75 Aspropyrgos refinery (source: https://www.tripinview.com/en/places/residential/55736/greece-attica-central-attica-aspropirgos)

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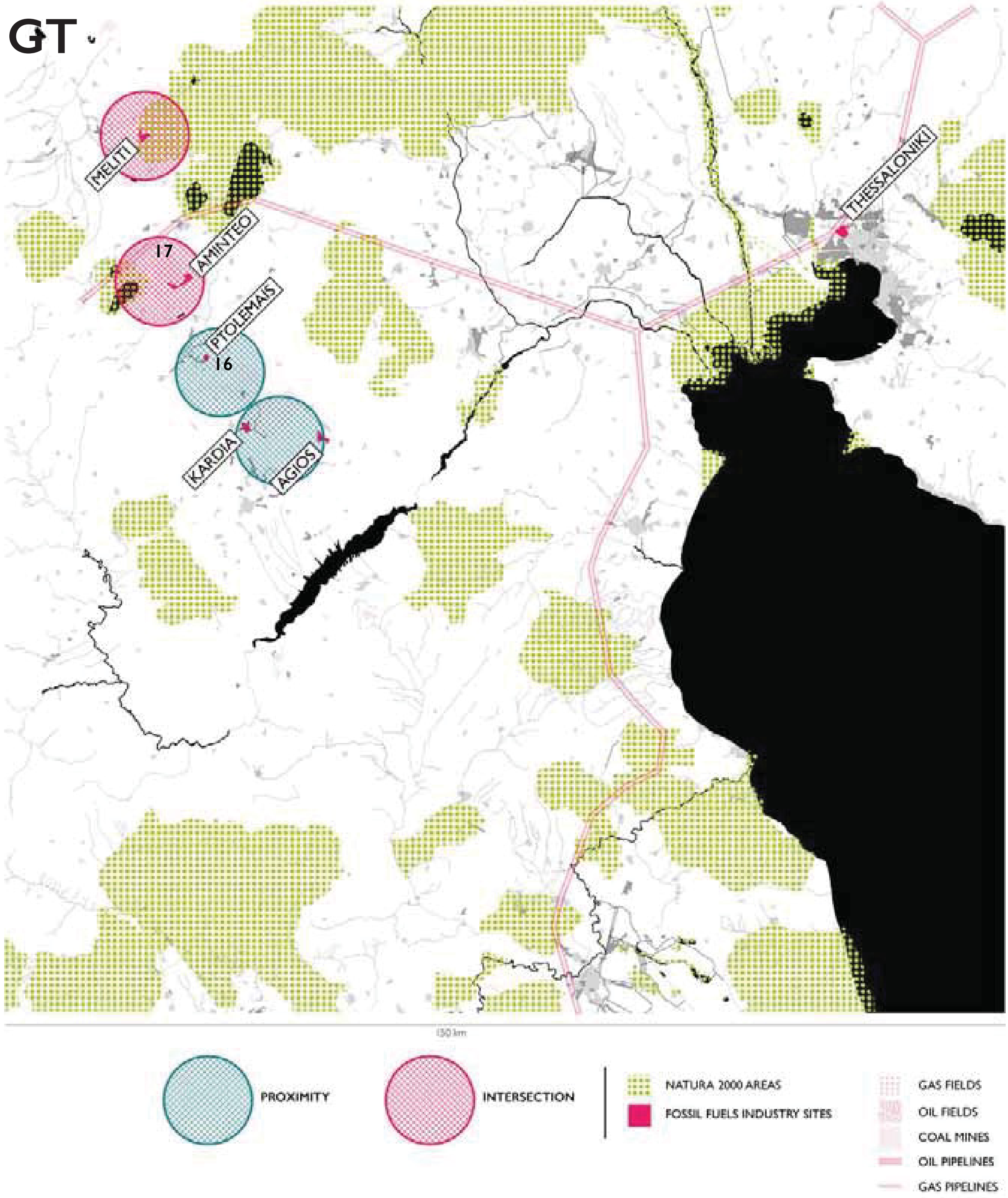


sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- Natura 2000 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

PROXIMITY #16

Fig. 76 Ptolemais lignite mines (source: https://www.vice.com/gr/article/53z378/ta-oryxeia-tis-dei-katapinoun-xoria-stin-ptolemaida)

Fig. 77 Ptolemais lignite mines (source: http://mashable.com/2014/11/12/lignite-greece/#NQtmgOSMbOqH)

INTERSECTION #17

Fig. 78 Aminteo power plant (source: Wikipedia)

Fig. 79 Aminteo lignite mines (source: http://blogs.agu.org/landslideblog/2017/06/13/amyntaiou-2/)

Oil infrastructure: between palimpsest and milieu

palimpseststructure

According to the Swiss thinker André Corboz (1983), "territory as a palimpsest" is the result of natural, spontaneous and anthropic transformations, which together contributed in defining a territorial morphology.
As already seen before, industrialization process is carrier of specific settlement patterns and of territorial infrastructure, being the principal economic organizer of the landscapes of the two industrial revolutions, which are descriptive of a specific socio-economic and cultural context (Castells, 1973).
From the end of the XIX century, oil represents "a critical agent in shaping global geographies – urban, rural and maritime - through physical infrastructure at major production sites, along networks of consumption, and through intangible, international flows of the finances, people, and ideas that sustain it"(Hein, 2013, p.437). Being oil infrastrcucture the so called "cathedrals of the modernity" (Branzi, 2006) for energy production of the second industrial revolution, we may be wondering that they are part of our industrial cultural heritage, because they represent the material and physical expression of the socio-economic ideological framework of a specific historical context. Their active role in the territorial restructuring of the third industrial revolution could contribute to set innovative and competitive local development strategies.

What fossil fuel infrastructure left on territories is not only limited to physical artifacts, but rather they brought know-how and experiences through the consolidation of an industrial sector that needed a vast and diversified network of local small-medium enterprises which worked in synergy for oil giants' needs. This is the reason why we think that we have even to take into consideration how the relationship between space and society historically shaped deep territorial identities, the so called *milieu* (Governa, 2001). Two are the possible approaches:

- the first one, as advocated by G. Dematteis (1995), looks at *milieu* as a local and permanent set of natural and socio-cultural conditions that have stratified in a certain place over time, which represent the common heritage of a local community and the territorial basis of its identity, so focusing on socio-spatial relationships principally established in the past;
- in the second approach, Governa (1997) defines the *milieu* not only as the territorial basis for a collective identity, but also as the local substrate for a future development process. In this way, heritage and project, identity and development become complementary. The *milieu* is not only constituted by features related to the past, but it suggests the potentialities that these features assume in the present in relation to the actions and projects carried by local actors. Potentialities and local values are not permanent,

but they produce and reproduce themselves as resources for development processes only if they are recognized, interpreted, used by a specific social organization. Quoting A. Berque (1990): "society perceives its milieu according to its use; mutually, society uses it according to the perception that it has*"*.

As underlined by Magnaghi (1998), the concept of *milieu* marks a fundamental step from a functionalist and abstract concept of territory as a *support for anthropic functions* to a notion of territory as a *heritage to be valued.*

Two are the lessons we can learn from this geographical and theoretical excursus:

- leaving aside the *tabula rasa* approach which has charcterized the modernist era, we believe that oil infrastructure is part of the territorial *palimpsest* we have to work with and, being an already existing widespread infrastructure, it would be useless to eradicate it. On the contrary, the real question is how to integrate and what role this infrastructure could play in the perspective of a territorial restructuring based on completely different socio-ecological values from those technical and engineering ones for which fossil fuel infrastrucuture has originally been designed;
- oil industry left deep tangible and intangible marks on territories concerned by its presence. We can imagine that heritage and project, identity and development have to converge towards a *milieu* notion that looks at energy production field as a feature and a potentiality to imagine new territorial development strategies which update the already existing know-how in the light of the energetic transition's needs.

It is certain that the value of oil infrastructure depends on multiple criteria, such as the typology of the plant, the construction period and the technologies used. This means that the tangible heritage of oil industry has not the same value everywhere, creating completely different relationships with the territory and local communities. In some cases the architectural heritage can be considered as industrial archaeology, in others territories have harmoniously integrated the infrastructure, so enlarging the experience at a bigger scale than the architectural one. This is the reason why we decided to analyze three case studies of reconversion of oil infrastructure which can somehow symbolize three different possible strategies and scale of intervention:

- a *punctual* approach for cultural purposes;
- a *network* strategy which combines cultural landscapes to local development;
- a *systemic* design for a more equitable redistribution of the well-being.

THE OIL MATERIAL HERITAGE

The **oil museum** at Merkwiller-Pechelbronn (Alsace, France)

point

The Pechelbronn Oil Museum was founded in 1967. From 1981, it is managed by the "Association des Amis du Musée du Pétrole de Pechelbronn" and from 1994 it has joined the network for the Musesum Conservation of the Regional Natural Park of Northern Vosges.

Alsace is one of the oldest oil regions in Europe. The presence of oil in the Pechelbronn area dates back to the XV century and will deeply mark the development of this region until the closure of the plants in 1970.
The first proven oil uses are placeable around at the end of the XV century for medicinal purposes, but only during the XVIII century oil started to be used for energetic purposes.
The first distillation laboratories were built in 1740, making Pechelbronn one of the oldest refineries in the world. In 1770, the first oil-mining company in the world was created in order to extract oil in Pechelbronn. According to Vergnaud-Goepp and Weinling (2015), during the XVIII century some wells were excavated in order to trace bituminous sands and exctract oil for medical uses. At the end of the XIX century, with the development of the refining process, oil was processed to obtian modern by-products.
During the First World War, technological innovations were introduced as oil demand was growing and production should follow accordingly. Thus, a dense deep oil recovery system (up to 400 m) was realized using mines tunnels.
The refinery plant was built during the '20s.
In its most brilliant era, the Pechelbronn oil industry employed more than 3'000 workers. Together with the oil wells, Pechelbronn oil landscape accommodates some offices, laboratories, the refinery, a neighborhood for engineers and one for workers and a private railway.
Most recently, after the closure of the oil industry, some studies conducted on the subsoil have verified the possibility of exploiting the deep geothermal potential of the region for energy purposes.

The Pechelbronn Oil Museum was founded in 1967 before the cessation of the activities. The collection is composed by objects, documents and photos which allow to retrace the 500 years of oil history in Pechelbronn, deepening several themes, such as the various oil extraction techniques, the refining processes, the industrial innovations and the main by-products which were processed on site.

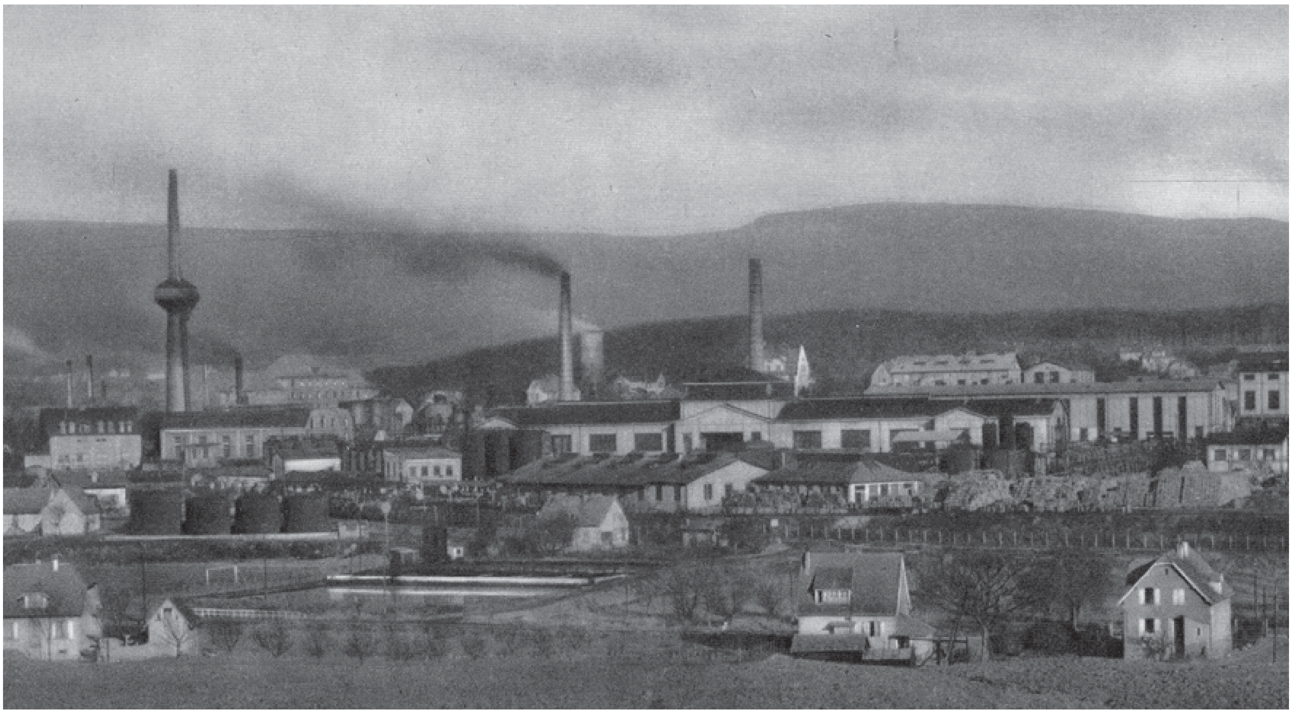


Fig. 80 Historical photo of oil refinery in Merkwiller-Pechelbronn (source: Musée du Petrole de Pechelbronn)

Fig. 81 Industrial archaeology of oil wells in Pechelbronn (source: Musée du Petrole de Pechelbronn)

THE CULTURAL LANDSCAPES OF OIL PROTO-INDUSTRIALIZATION

network

The **oil museum park** at Fornovo di Taro (Parma, Italy)

The research project "Estrazione del petrolio e cultura tecnologica a Fornovo di Taro (PR). Conservare, esporre e divulgare i saperi scientifici tra didattica e valorizzazione", conducted by Laboratorio di Ricerca Architettura Musei Reti - AMR belonging to the Department DICATeA of the University of Parma, with the support of the Municaplity of Fornovo di Taro and GasPlus, has been financed by MIUR - Ministero dell'Istruzione, dell'Università e della Ricerca of the Italian Governement

Vallezza oil fields, situated on the Appennines in the province of Parma, represent the oldest Italian oil extractive site. Indeed, since the mid-1700s, the site was already well-known for an abundant oil presence which naturally gushed up to the surface in the middle of agricultural fields and it was picked up in very small quantities for indoor and urban lighting. At the end of the 1800s, oil extraction was still done in small quantities by means of ordinary wide section wells. In 1905, the SPI (Società Petrolifera Italiana) was founded in order to extract oil from Vallezza oil fields with industrial tools and to improve the performance of the existing Fornovo refinery. But industrialization in Italy was late to arrive and we have to wait until the 1930s, under the Fascist regime, to witness the first real industrial development in oil extraction and refining domain when Fornovo oil site passed into the hands of Standard Oil (one of the American oil giants) and, thanks to local know-how and labor force, an innovative pumping system was realized in order to operate the extraction from several wells at the same time. Extraction activity in Fornovo ceased in 1987 and in 1994 the entire oil field was declared depleted. The end of oil activities in Vallezza also coincided with the end of the development of a territory which began to depopulate.

Since the beginning of the XX century, oil industry has been the principal source of wellbeing for the local community of Fornovo, bringing work and new infrastructure to local inhabitants, and deeply changing the agricultural vocation of the territory in favor of a new industrial identity which, in its protoindustrial expression, did not compromise that previous harmony between anthropic interventions and the natural environment. Nature and industry blend into a continuum that associated the wooden perforation towers along the ridge to mountain paths and to fruit trees fields in order to make the local community an active participant in the daily life of the mining site.

According to Bruzzone (2015), five are the criteria through which it is possible to interprete the whole Vallezza oil industrial expression as *cultural heritage*:

1. SITE: the oil extraction area is situated on a ridge, which, in the past, was already a naturalistic and sport touristic destination, touched by the historical

Fig. 82 Oil proto-industrialization in Vallezza (source: Gas Plus Italiana srl)

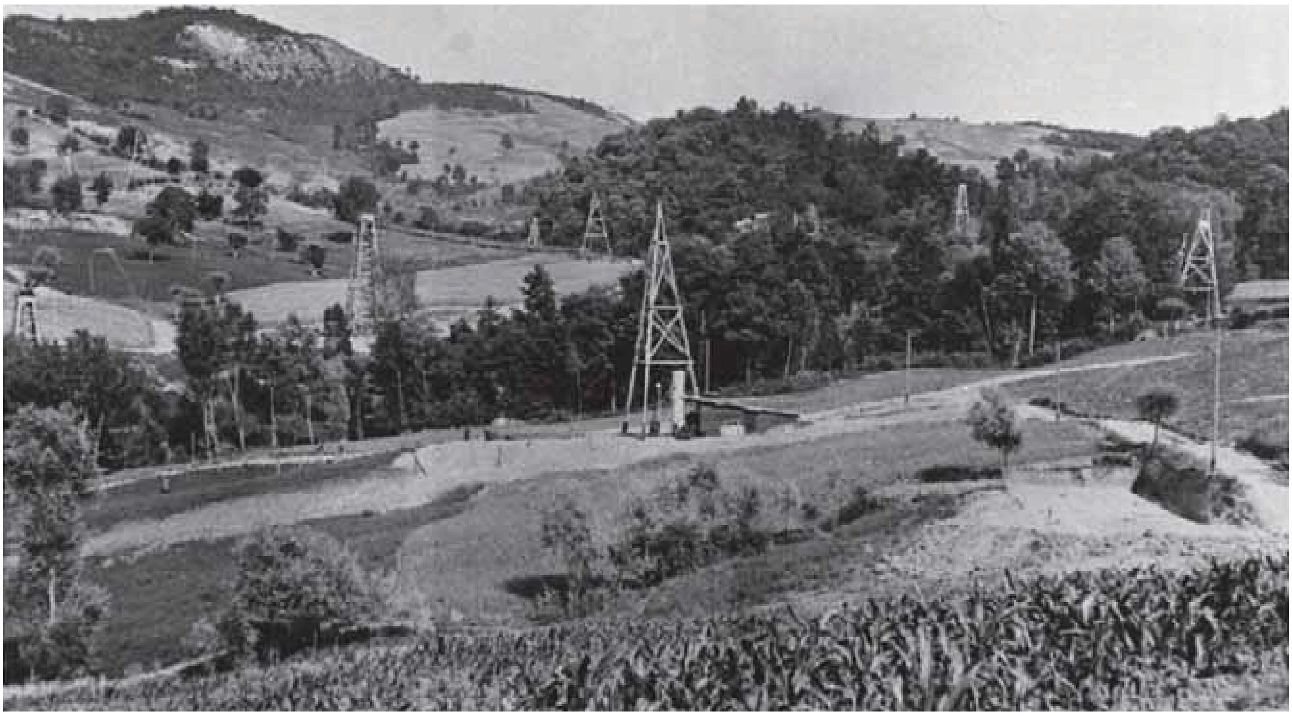


Fig. 83 Oil proto-industrialization in Vallezza (source: Gas Plus Italiana srl)

Francigena Route and by the European cycle route;
2. INDUSTRIAL BUILDINGS: the built heritage is made up of some well preserved industrial buildings that allow to savor the original industrial spirit. The artifacts of the refinery and of the pumping stations are recognizable, within which it is still possible to admire those oil extraction machineries which witness a unique method of oil extraction in the Italian national panorama, precisely known as Fornovo method;
3. INDUSTRIAL LIFESTYLE: the proximity of Vallezza miners' village to the extraction site provided necessary services to workers and their families, so confirming the intention to create a small mountain community rather than just a mining working site;
4. INDUSTRIAL MATERIAL HERITAGE: a large stock of industrial machineries for drilling, mining, oil exploration and for the classification of oil samples of the 179 oil wells of the area constitutes the legacy of a productive past for a local identity;
5. INTANGIBLE HERITAGE: the widespread immaterial heritage, made up of experiences, memories, know-how and productive practices, represents the binder among man, history and territory that allows to define Vallezza oil expression as a *cultural landscape.*

Cultural landscape is a category of cultural heritage introduced by Unesco (2016) in the *Operational Guidelines for the implementation of the World heritage Convention of 1972*. According to this definition, the joint work of man and nature that illustrates the evolution of human society and of its settlements over time can be defined as a *cultural landscape*. In particular, the specific category of *associative cultural landscapes* focuses on that above-mentioned intangible cultural heritage which allows to associate to material and physical expressions

Fig. 84 Mu.PE. Parco Museo del Petrolio delle Energie (source: Parco Museo del Petrolio)

those ideas, beliefs, symbols or traditions which are carriers of a specific cultural identity.

The intent of preserving such material and immaterial cultural heritage lays the foundation to Bruzzone's proposal of constituting an **Oil Museum Park** which would allow people not only to experience oil industrial archaeology, but even that tight bond among man, oil and territory which characterized the construction of a unique landscape. Bruzzone (2015) interpretes "*territory as an active museum, which excludes the integral conservation of the site as an immutable background for preserving and exposing, making it synonymous with vitality" (translated in English by the author).*

As asserted by Massarente (2015), "*the real potential of this interest towards the interaction between anthropic actions and natural habitats looks at developing territorial marketing strategies, such as those related to cultural districts: local economic development models, territorially defined, based on an organized system of relationships between products and territory aimed at promoting a local process intended to produce culture" (translated in English by the author).*

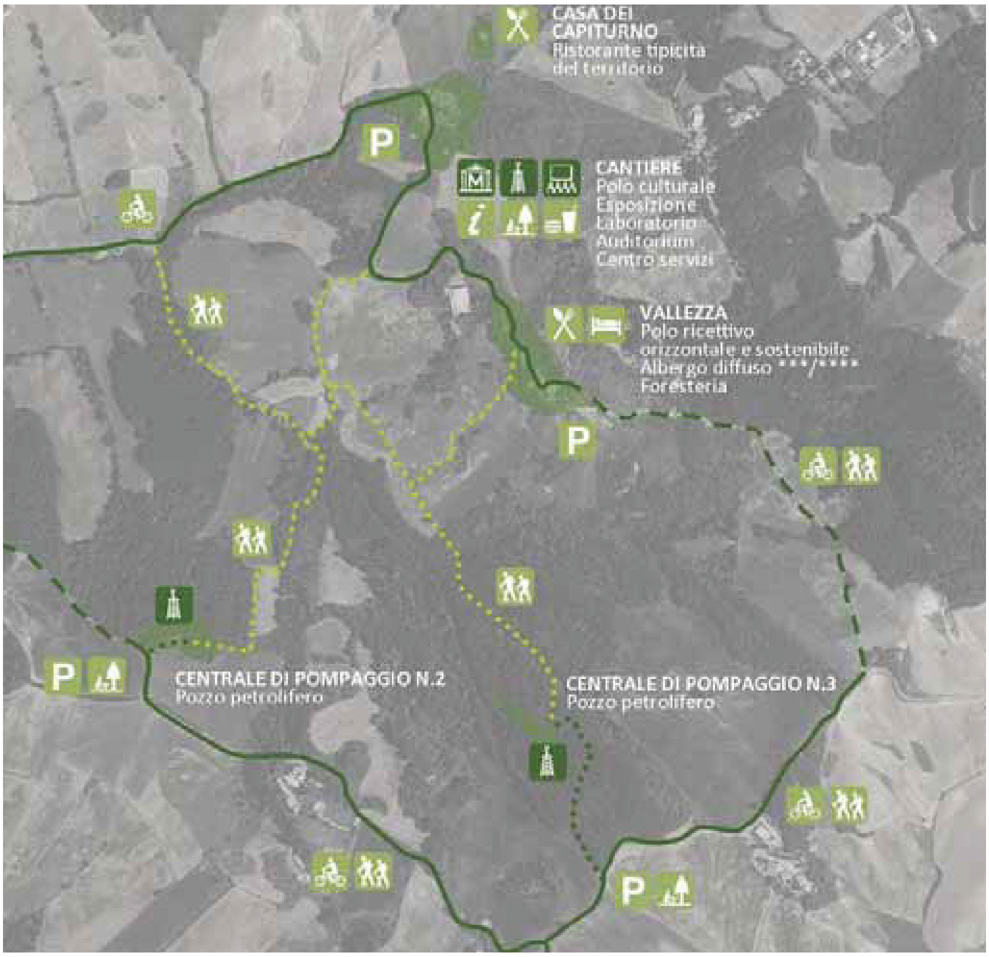
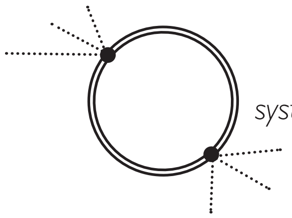


Fig. 85 Parco Museo del Petrolio di Vallezza (source: Parco Museo del Petrolio)

THE DEMOCRATIZATION OF FOSSIL FUEL PIPELINES



Hydroscapes for Uruguayana-Porto Alegre Pipeline (Brazil)

The Petropolis of Tomorrow is a multidisciplinary research directed by the architect and urban designer Neeraj Bhatia (InfraNet Lab / The Open Workshop) in collaboration with SAP (South American Project), Harvard's Graduate School of Design, California College of the Art's Urban Works Agency, Rice University's School of Architecture, Cornell's University's Department of Architecture

As highlighted by Correa (2013), the *Petropolis of Tomorrow* applied research proposes a critical perspective on the phenomenon of urbanisation which derives from oil extraction process in South-America. The aim of the research is to suggest how new forms of urbanity, including the basic settlement requirements for oil extraction, can be thought, in order to propose innovative alternatives to those urban agglomerations which are generally devoid of any organizational and social thinking being the mere result of oil companies' interests.
The results of the research are principally organized through two dissemination tools: a book (*The Petropolis of Tomorrow*, edited by Actar 2013) and a website (www.petropia.org).

The main publication collects theoretical texts of renowned international researchers, organizing their contributions around three principal axes: *Archipelago Urbanism*, *Harvesting Urbanism* and *Logistical Urbanism.*
The *Archipelago Urbanism* part investigates around the role of oil infrastructure as *islands* and their reciprocal relationships, looking at off-shore infrastuctures as the main starting background.
The *Harvesting Urbanism* section reflects around the dependence of urbanisation processes on a monotype resource extraction, and questions territories about the possibility to integrate multiple harvesting combinations.
The *Logistical Urbanism* part explores the role of oil logistics (midstream and downstream) in urban forms' organization.
At the end of every part, some design project scenarios are presented.

The website principally focuses on the presentation of alternative urban form scenarios which respond to the three above-mentioned categories of urbanism, organizing them through three different strategic approaches: *Floating*, *Oil Endpires* and *Wiring.* Among them, we would like to focus on the *Wiring* strategy, because we think that it is the one that better allows us to widen the spectrum of our previous reflexions about *palimpsest* and *milieu* notions.

Fig. 86 Phasing of energy ring (source: Blake Stevenson)

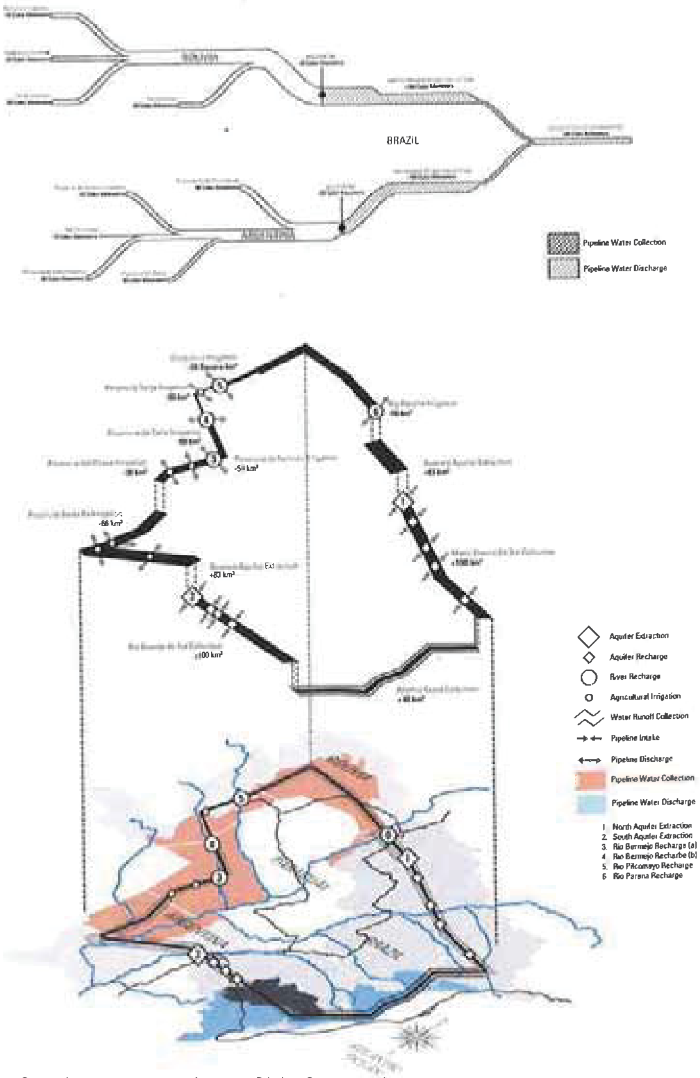


Fig. 87 Masterplan of pipeline energy ring (source: Blake Stevenson)

The case study has been published on Volume 47 by Bhatia et al. (2016) as a challenging theoretical reflexion about the role of territorial systems.
Indeed, the basic assumption proposed by Bhatia and his team is that oil infrastructure will have a longer lasting presence on territories than the resources for which they have been built (Bhatia reminds us that average oil lifespan is estimated in about 40-50 years[1]). In some cases, like the Brazilian one, oil lifespan collapses to 25 year, but kilometers of oil infrastructures are still being built to optimize the immediate return without questioning their long-term utility. Thus, Bhatia suggests that a future productive role for that infrastructure should be inclusive of *cultural, political, ecological and economic factors.*
If the main aim of pipelines is to connect far extracion and refining sites, the principal characteristic is that they cross over hundreds of kilometers of territories which are only touched by environmental costs, but by no benefits for local communities. While, on the one hand, we recognize the role played by this infrastructure in the construction of the *palimpsest* of those remote areas, on the other one it seems that pipelines completely move away from the *milieu* concept. Indeed, they are not absolutely involved in the construction of a local identity based on the relationships between oil, man and territory, or even worse, they negatively influence the environmental conditions. But the possibility to intervene on the future role of that infrastructure could completely change the situation, looking for a sort of compensation *"for deprived settlements and ecologies that will inherit these infrastructures"* (Bhatia, 2016). Pipelines could be reframed in order to connect people and environments.

The Uruguyana-Porto Alegre Pipeline runs over 3'100 kilometers through Brazil, Argentina, Bolivia and Uruguay, crossing completely different landscapes and social conditions. The extension of the territories overtaken by that pipeline, together with the climate change we are witnessing, leads to the definition of two macro-regions that are facing completely different challenges. If the ongoing desertification phenomenon of Gran Chaco Region (the central region comprised among Argentina, Paraguay and Brazil), due to deforestation and aggressive farming techniques, will be the cause of a widespread water and food scarcity, Eastern Coasts of Brazil are reporting a growing increase in precipitation and flooding.
The reframing of the second life of Uruguyana-Porto Alegre pipeline proposed by Bhatia looks at playing an active role for a sustainable water management scenario. In fact, the pipeline crosses the second largest underground aquifer basin (Guarani Aquifer), thus a *hydroscape reconversion scenario*, which provides

1 Smith, L. (2014), *World Energy Day 2014: How much oil is left and how long will it last?* in International Business Times (October 22, 2014)

for the water transport in combination with the aquifer to balance extraction and recharge, could contribute in balancing the environmental and social conditions of two risk disaster areas. As Bhatia asserts, *"hydroscaping the larger territory is not simply reverse climatic trends, but rather to empower local economies in the hinterland that might benefit from the pipeline".*

Four are the territorial visions which should be put in place according to specific geographies along the pipeline ring:

- collection and remediation along the Atlantic coast;
- water banking and aquifer recharge on the coastal interior in former quarries; • water extraction and food logistics along the western edge of the aquifer;
- surface recharge sites that interface with natural rivers.

The reconversion of fossil fuel infrastructure establishes new relationships among pipelines, local economies, communities and resources.

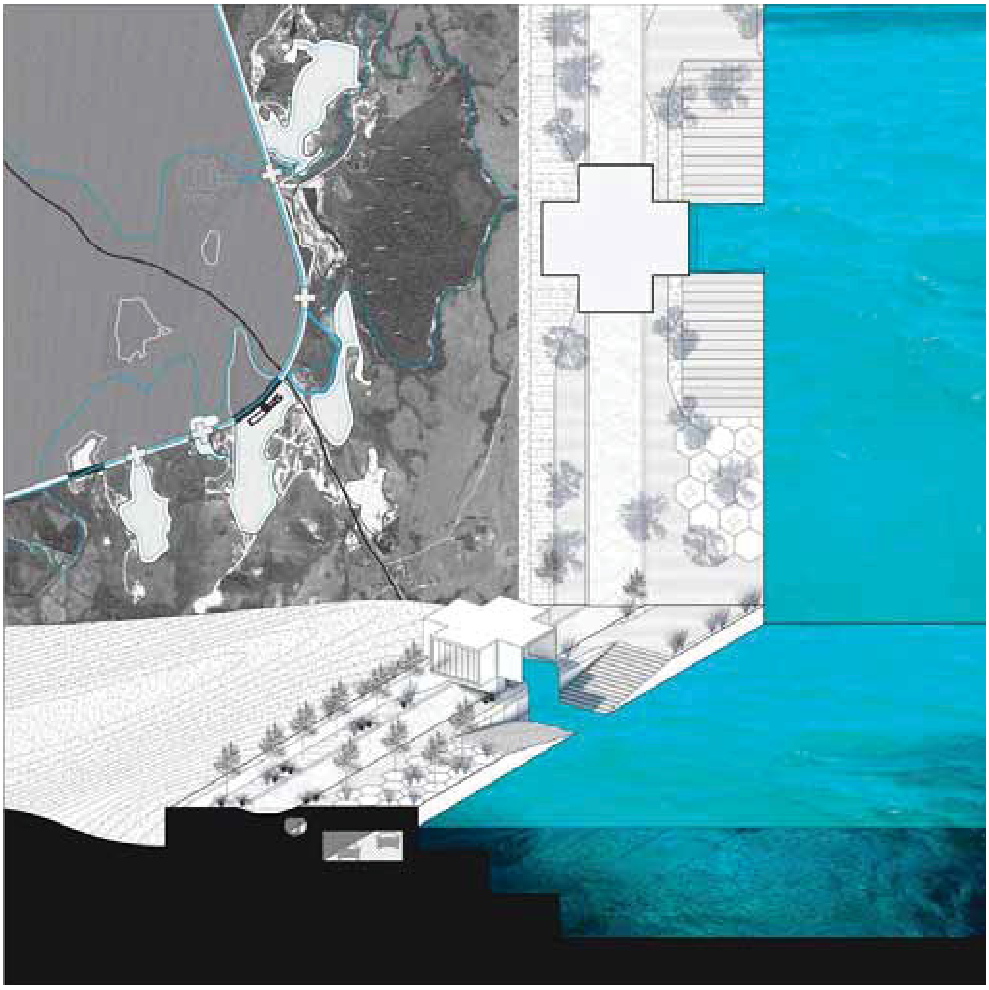


Fig. 88 Hydroscape: critical nodes within the logistical system (source: Lujac Desautel)

From oil infrastructure to oil meshes

territorial restructuring

Thanks to the theoretical and territorial analysis carried out in the previous paragraphs, it is evident that the widespread territorial network of physical and functional connections among upstream, midstream and downstream sectors represents the real potential for reframing oil infrastructures. Questioning their role in the light of the energetic transition signifies to consider them as a whole, as territorial *oil meshes,* in order to *de-engineer* (Bélanger, 2012) their original technical function and to establish new hierarchies with territories and local development processes, which cannot escape from a deep restructuring of energy production system towards a more democratic and distributed model, based on renewable energies' exploitation.

The current shift of energy infrastructure's policies from centralization to territorial distribution could be pivotal in the definition of the new territorial role of fossil fuel infrastructure, looking for innovative local development processes which don't look anymore at territory as a resource to be exploited through infrastructure, but as a non-renewable resource to be valorised through landscape.

Fig. 89 Les villes rangées: Berlin (source: Armelle Caron)

destructuring? The necessity to define a new *narrative* for oil meshes forces us to reflect about the *figure-background* relationship that has characterized infrastructure planning up to now, making the territry a mere passive support to the functional needs of infrastructure.

With the sole purpose of finding a metaphor to better define a possible strategic approach, we would like to consider Armelle Caron's artwork project *Les villes rangées*, which suggests an interesting key lecture for the redefinition of hierarchies between background and figure. The artwork plays with this relationship through the extrapolation of some urban portions of some European metropolises. It is evident that through this two-color representation, the element that gives meaning to the *figure* (urban fabrics) is the *background*, which is to say the vacuum, the infrastructure.

As the rules change and elements forming the *figure* are ordered by following different criteria (for example, by similarity of shape, size, etc.), it is no longer possible to recognize that single parts belong to an urban fabric and the morphological relationship between *figure* and *background* is completely lost.

This project seems to mean that we can undermine existing hierarchies working with what already exist, with the *palimpsest*, thus it is possible to imagine to *de-structure* or *disassemble* the established hierarchies between oil infrastructure and territory in order to integrate multi-scalar socio-ecologic dimensions.

Fig. 90 Les villes rangées: Berlin rangée (source: Armelle Caron)

PART III

Energy territorial hierarchies

A historical analysis of the Ruhr region

Not by chance one of the most impressive first industrial revolution development settled up in the Ruhr region, in the Western Germany. The reasons date back to Carboniferous era, something like 320 million years ago, when the equator passed right by this region and the hermetically-sealed compressed vegetation in the marshy lowlands of a vast coastal landscape gradually petrified and became coal. Nevertheless, mining was a very hard activity in the *Ruhrgebiet* (the German term used for the Ruhr region) due to a very thick geological stratification. If in the southern part of Ruhr coal emerged up to the soil surface and, during a pre-industrial stage, mining activities were therefore facilitated along the Ruhr river, further north, towards Emscher and Lippe rivers, coal was covered by ocean sediments and was located more than 500 metres deep.
Several are the key moments which determined the principal geographical and morphological transformations due to a massive industrialization phenomenon which shaped Ruhr landscapes for over a century.

until 1840
pre-industrialization period

At the beginning of the XIX century, Ruhrgebiet was still an agricultural area, characterized by small, handicrafts and semi-rural towns of about 8'000 inhabitants. Coal mining activities in the region, although in very small quantities, were known since the Middle Ages. The Ruhr river was the main transport infrastructure to carry the small amounts of coal to Rhine harbours, together with some horse tracks which connected Ruhr river to urban areas along the *Hellweg trading route*[1]. We have to attend until 1840s to witness a real proto-

1 The Hellweg trading route is an historic medieval transit route which connected the Ruhr region to the Atlantic Ocean going west and with Poland and the Baltic sea, passing through Duisburg, Essen and Dortmund, going east.

industrialization process, principally due to two main factors (Reulecke, 1984):

- a technical innovation in deep coal mining, which allowed to go down 600 m and catch bituminous coal, necessary for coke production and then for steel production;
- a consequent rapid extension of the railway network.

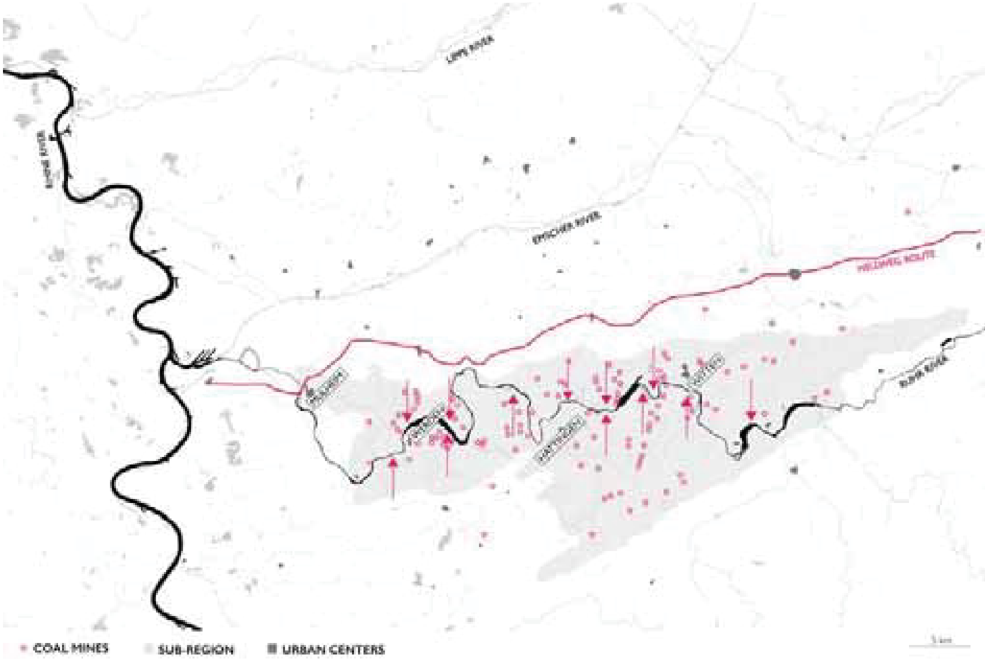


Fig. 91 1840 / Ruhr river region pre-industrialization (source: Steinberg, annex 1; redesigned and reinterpreted by the author)

1840-1860
proto-industrialization period

Afterwards, deep coal mining sites started to spread all over the *Hellweg strip*, a sub-region comprised between the Emscher and Ruhr rivers and crossed by the homonymous trading route. The spread of railways all over the region accompanied the remarkable opening of several new mining sites, allowing rapid connexions from extraction sites to heavy metal industries and blast furnaces. New collieries and iron plants were settled up in rural contexts close to small, semi-rural villages along the Hellweg trading route, so boosting a huge urban growth, which continued for more than a century until the 1970s (Hötker, 1988). Recognizing the pivotal role of Hellweg strip's industrial expansion, the regional railway network developed along a north-south axis in order to connect the southern Ruhr river's mining sites to the main urban centres lying on Hellweg route. Between 1840 and 1860, the growing importance of those mining and industrial areas produced a remarkable phenomenon of short-distance migration, which brought some new 50'000 residents towards the peripheral areas of main urban centres along the Hellweg route. The existing towns did not possessed in their internal dynamics those driving forces justifying that urban growth. In fact the real economic boost was situated at their fringes, in semi-rural locations, where mining and metalworking companies settled up their activities together with huge and dense workers' colonies to accommodate new inhabitants arriving from agricultural areas (Reulecke, 1984).

According to Günter Steinberg's map (1967), in 1857 Ruhrgebiet looked already like a continuous industrial landscape rooted on coal extraction and on heavy metal industry. Three hundred coal mines, several iron ore mining sites, blast furnaces, water-powered mills, together with a dense private profit-oriented railway infrastructural network scattered the Ruhr territories. The former semi-rural villages were wrapped by industrial expansion and by workers' colonies in the outskirts.

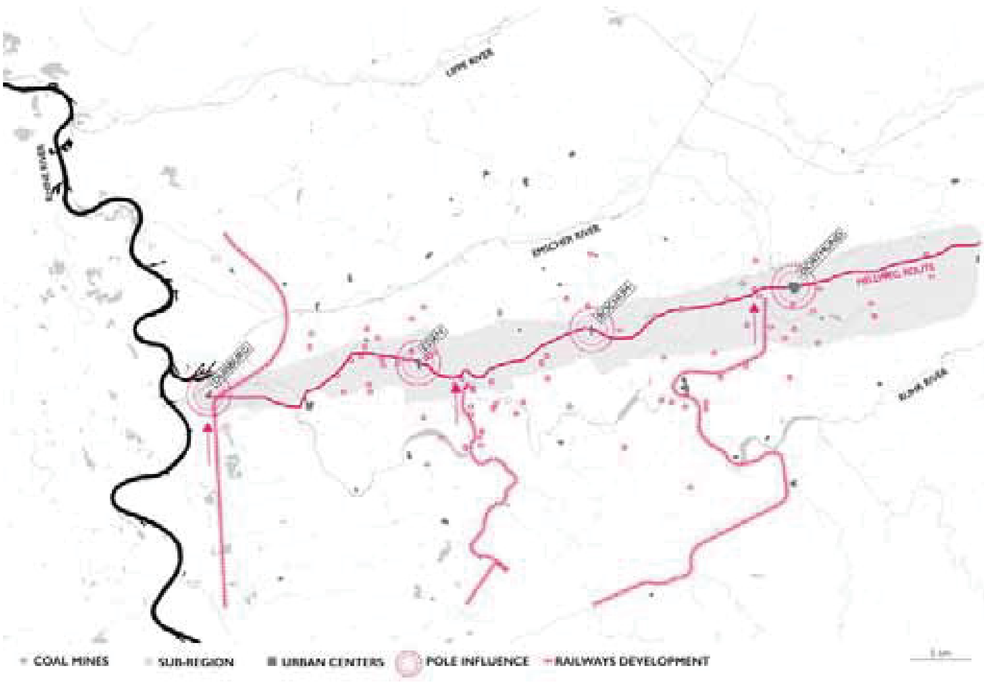
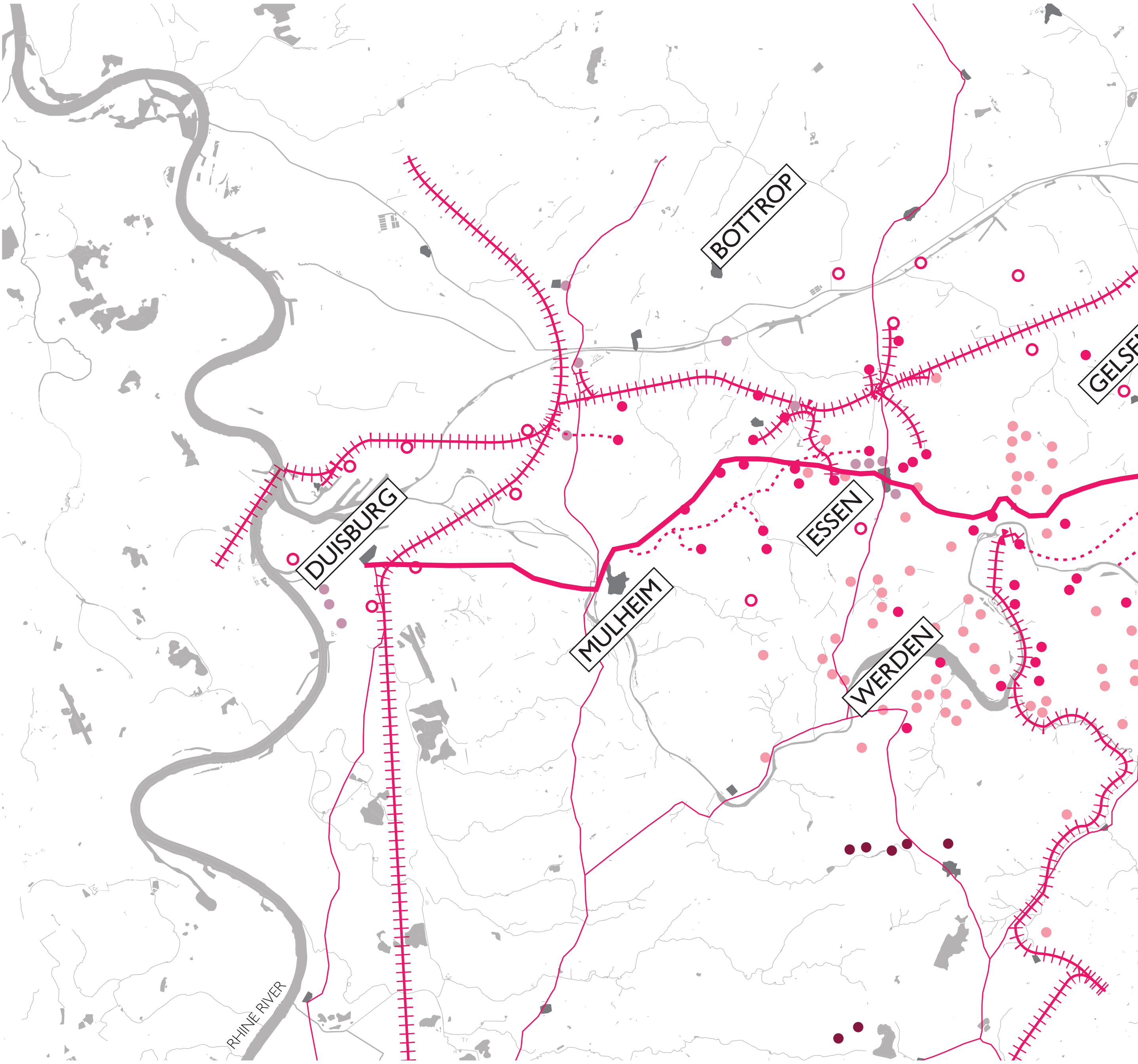


Fig. 92 1840-1860 / Hellweg strip region proto-industrialization (source: Steinberg, annex 1; redesigned and reinterpreted by the author)

1860-1890
massive industrialization period

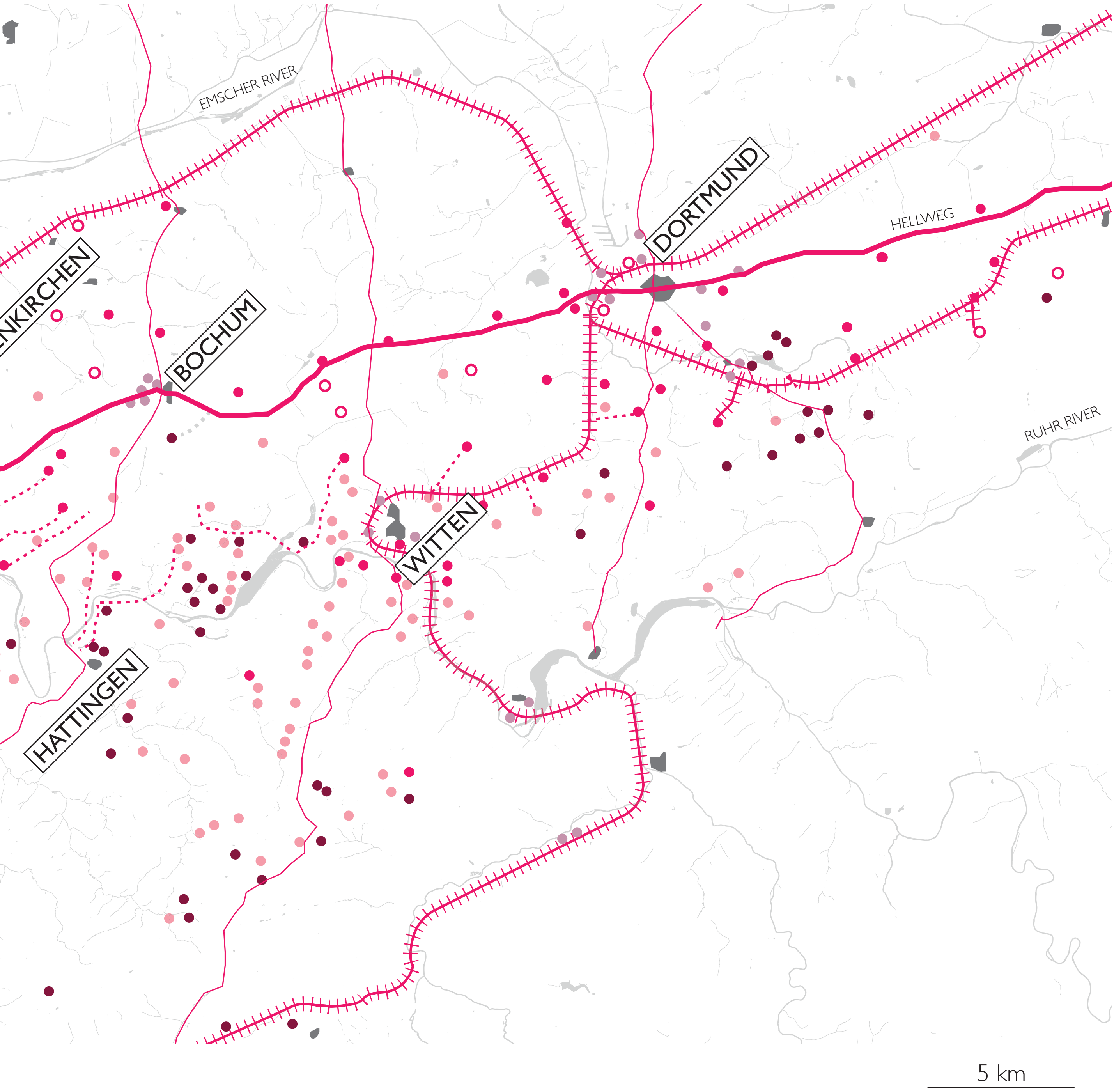
Nevertheless, the *golden age* of Ruhr industrialization was not yet experienced. The spread of the railway network reached the northern part of the Hellweg strip, towards the Emscher river sub-region. There, a sparsely inhabited situation encouraged the implementation of a profit-oriented planning of railway infrastructure, managed by private owners of coal mines and of industrial sites. A principal east-west railway axis was realized, parallel to Emscher river, fostering the development of several secondary railway branches catching new coal mining basins. This railway infrastructure became the principal backbone along which the sparsely inhabited territories settled up their industrial expansion (Oberhausen, Gelsenkirchen, Herne). At the end of the XIX century, more than 800'000 migrants came to Emscher river sub-region (Reulecke, 1984).



DEEP COAL MINES
PLANNED DEEP COAL MINES
OTHER COAL MINES
IRON ORE MINES
OTHER MINING SITES

HELLWEG ROUTE
ROADS
RAILWAYS
HORSE TRACKS
TOWNS

Fig. 93 Ruhrgebiet in 1857 (source: Steinberg, annex 1; redesigned and reinterpreted by the author)


EMSCHER RIVER
NKIRCHEN
BOCHUM
DORTMUND
HELLWEG
WITTEN
RUHR RIVER
HATTINGEN
5 km

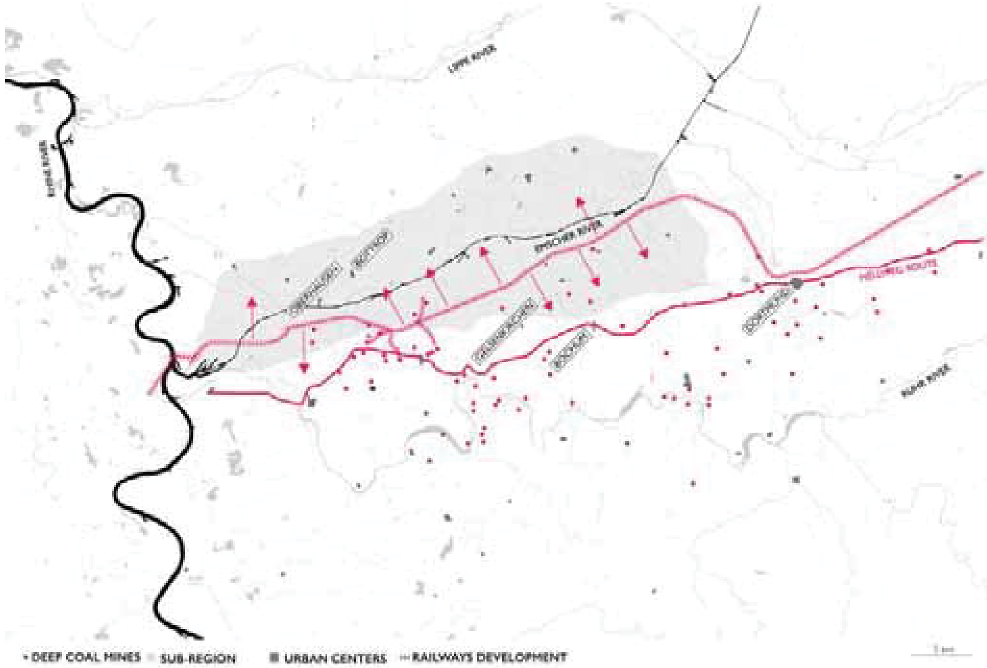


Fig. 94 1860-1890 / Emscher strip massive industrialization (source: Steinberg, annex 1; redesigned and reinterpreted by the author)

The principal mine shafts were set up away from existing urban centres, so miners' dwellings sprawled in the countryside preventing the formation of few concentrated urban centres.

1910-1930
stabilization period

During the World War I and until the rise of national-socialism in the 1930s, principal industrial areas in the Ruhr region affirmed their international predominance in coal and heavy industry, but it was not a period of remarkable industrial expansions.

1930-1945
re-agrarianization period

During the Third Reich, Hitler imposed to Ruhr region some re-agrarianization policies in order to disperse the big industrial concentrations and to relocate workers in the distant rural surroundings (Reulecke, 1984).

1945-1968
petrochemical industrial development

Only after the World War II, from 1945 to 1960, Ruhrgebiet witnessed another industrial development era in its northern part towards the Lippe river sub-region. While coal industry was collapsing, the cooperation between coal and petroleum chemistry boosted the settlement of petrochemical complexes on Lippe river banks (Hötker, 1984). It is remarkable how the Lippe river sub-region, being characterized by a tardive industrial development from the second half of the XX century, lacks that dense railway network mostly built in the XIX century in the southern Ruhr sub-regions. On the contrary, its industrialization better responds to vehicular mobility infrastructure. Anyway, from a regional point of view, Lippe river sub-region was still considered as an agricultural and rural forestry belt suitable for recreational uses of the Ruhr region's residents.

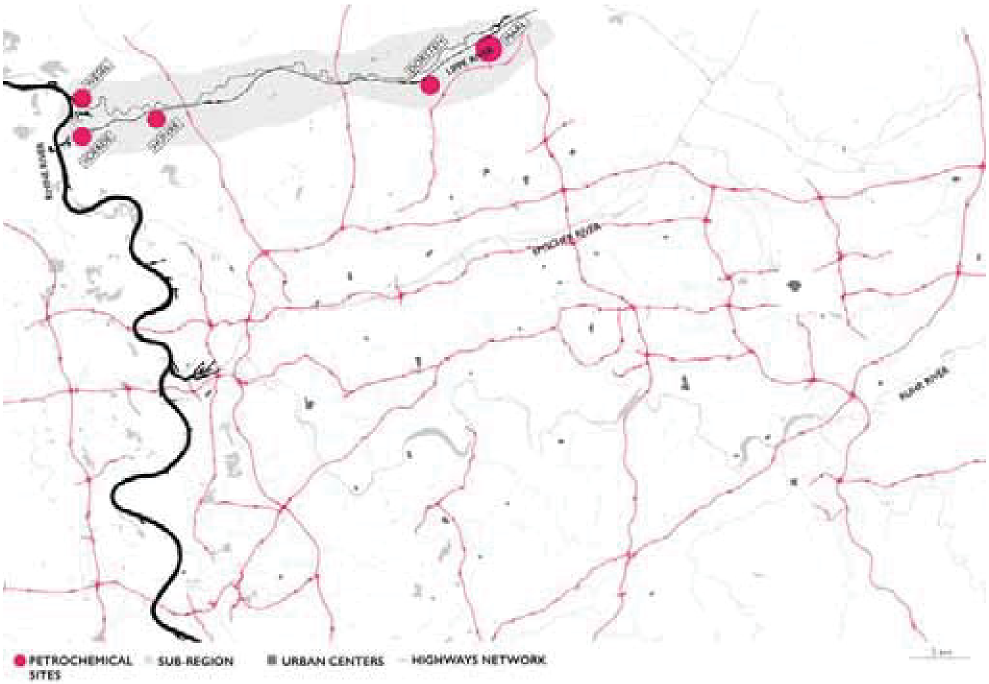


Fig. 95 1945-1968 / Lippe strip petrochemical industrial development (source: Diva-gis; elaborated by the author)

Ruhr regional planning debate in XX century

The territorial planning experience of the Ruhr region at the beginning of the XX century represents a pioneering milestone for a still contemporary holistic planning approach, which involves urban, infrastructural and environmental domains.

It is worthwhile to remember that, before the World War I, the Ruhr coalfield agglomeration had not yet experienced a territorial planning strategy which intended to achieve a coherent local development of industrial areas. On the contrary, the profit-oriented decisions of companies' owners shaped an uncontrolled and disordered urban and industrial growth. In order to give an example, until the nationalization of the railway network in 1894, nobody was imagining to develop a previously planned railway infrastructure network. Until the end of the XIX century, railways spread below private companies' interests principally for the transport of raw materials. In 1881, 20 million tons of industrial goods (coal, iron and steel) transited along the Ruhr railway network, prevalently along the well-developed East-West railway axis parallel to Emscher river, to reach 50 million tons in 1900 (Hötker, 1988).

At the beginning of the XX century, the political and territorial fragmentation issue started to be at the center of urbanists and politicians' debate. They wondered how to handle a regional growth which lacked a unitary structure and which was dominated by unhealthy living districts in proximity of industrial areas. In the light of the polycentric growth occurred during the previous 60 years, local authorities needed to answer a structural question for the definition of the development of Ruhr agglomeration: did the Ruhrgebiet need to be

organized and planned as a unique widespread *metropolis* or did it have to maintain its decentralized identity, reinforcing a *city of cities* model (Reulecke, 1984)?
The beginning of the XX century was pervaded by Camillo Sitte and Ebenezer Howard's theoretical influence about the necessity to restructure the polluted and unhealthy image of industrialized European metropolis through a planning activity capable of fleeing technicalities and claiming for the artistic and aesthetic role of urbanism. On the wave of this theoretical thinking, in 1912 the pioneering planning approach of Robert Schmidt (Deputy Mayor of Essen Municipality with responsibility for town planning) proposed for the first time a unique strategy for a coherent development of municipalities belonging to Ruhr region, which would have been federated under the notion of a "Ruhr metropolis" (Reulecke, 1984). From Schmidt's point of view, a general regional development plan of the Ruhr region's built-up area was necessary in order to impose a coherent and ordered growth which would have represented a valid alternative to the uncontrolled and private-driven urban and industrial growth. The similar socio-economic characteristics of the Ruhr territories allowed Schmidt to think that order had to be brought by overpassing local administrative boundaries. Schmidt's visionary *General Housing Estate Plan* (1912) proposed a regional growth vision based on the idea that industrial areas should have to be immersed in a national park which would have reconnected the Ruhrgebiet's cities and would have given qualitative recreational and leisure areas to workers (De Geyter, 2002). The real innovation of this planning approach consisted in its interdisciplinary and multi-scalar approach, which had to involve housing, recreation, work, transport, environment and aesthetic domains to be planned in a holistic and coordinated way looking at the development of the agglomeration. Schmidt's vision was partially realized in 1920 through the constitution of the *SVR - SiedlugsVerein Ruhrkohlenbezirk* (Federation of urban areas in the Ruhr mining district), that is to say the executive political and territorial planning authority which was in charge for the ccordination of a coherent urban and industrial planning for the Ruhr region, privileging the polycentric and federative vision to Schmidt's metropolis one. The role of SVR was to outline a "comprehensive environmental planning" extended to the entire Ruhr region (Reulecke, 1984), to which local municipalities would have to adhere in terms of territorial and infrastructural planning.
According to Schmidt's General Housing Estate Plan, three were the key axes in order to guarantee the preservation of the remaining natural and agricultural lands constrained in the urban agglomeration:

- the extension of the recreational areas for workers' leisure;
- the reconnection of existing open spaces, preventing residential development in areas polluted by industrial sites;

- the creation of *verkehrsbänder* (communication corridors), in order to allow residents and commuters to rapidly move between working and residential areas and to recreational ones. The development of an East-West motorway, which crossed city centres, outskirts and countryside from Dortmund to Duisburg, belongs to these mobility policies.

With the arrival of the 1970s and of the coal crisis, Ruhrgebiet industrial growth dramatically stopped and the whole region fell into a comatose state, characterized by a very high unemployment rate and by a growing number of dismissed industrial sites. After being exploited at their most, territories were left in catastrophic environmental conditions. The reduction of the role of the SVR, until its dissolution in 1974, deepened the territorial crisis, leaving huge abandoned portions of territories with no plausible scenarios of future local development.

territorial hierarchies

Thanks to the previous historical overview, it is evident how the industrial, infrastructural and urban domains are intertwined in the Ruhr territories.
Recalling the industrialization macro-trends that have already been anticipated in the previous paragraph, we would now like to proceed with a morphological analysis of the established hierarchies between urban and industrial development from 1840 up to now.

hierarchies before 1840

Several semi-rural villages scattered the Ruhrgebiet, in particular in its eastern part. The western area towards the Rhine river was scarcely inhabited, except for some important urban centres which were concentrated at the intersection of Ruhr and Emscher rivers and Hellweg trading route. The northern territories towards Lippe river were almost uninhabited.

hierarchies between 1840-1890

The vast industrialization growth, occurred between 1840 and 1890 in the area comprised between Ruhr and Emscher rivers, is characterized by some very recognizable trends:

- a punctual expansion of huge industrial poles in the western outskirts of the most important cities along the Hellweg trading route (Essen, Bochum, Dortmund);
- a linear development of industrial patterns parallel to the railway infrastructural network in those urban centres comprised between the Hellweg trading route and the Emscher river. Furthermore, as for Gelsenkirchen case, some linear industrial developments are parallel to two different railway branches, north and south of the city;
- no remarkable industrial growth trends are recognizable along the Ruhr river, whose urban centres seem to be left to a slowly growth.

As regards the development of urban areas, they seem to confirm the main morphological industrial growth tendencies, that is to say:

- a radial expansion of urban areas, until their industrial boundaries, of those urban centers settled along the Hellweg trading route (Essen, Bochum, Dortmund);
- a linear development of urban areas parallel to railway infrastructure in the Emscher river sub-region, even in those areas which were deficient of former semi-rural villages (see in example Oberhausen case), except for Gelsenkirchen, which confirms a perpendicular urban growth to railway infrastructure towards the south;
- urban centres along the Ruhr river don't present any relevant urban growth.

hierarchies between 1890-1957

During the sixty years comprised between 1890 and 1957, we witness a substantial consolidation of prior industrial poles, confirmed by a physiological growth of industrial and urban areas in a centrifugal way. The industrial edge moves towards the north and oversteps the Emscher river, but industrial settlements are of secondary importance. Two outstanding factors can be representative of this period:

- from an industrial growth's point of view, what is really notable is the massive industrialization process along the Rhine banks and, with the spread of motorways, the responding of some industrial areas to vehicular logics;
- from an urban growth's perspective, city boundaries are no more recognizable and they merge in a unique extending patchy built-up area which encloses some fragments of agricultural and natural landscape.

hierarchies between 1957-2012

From 1957 to 2012, we assist to two main growth trends of industrial areas:

- the opening of important industrial sites along the Lippe river;
- a tendential shift in the dependence of industrial areas from railway infrastructure to road infrastructure, which leads to the definition of some principal industrial development corridors that go beyond municipal administrative boundaries along north-south and east-west axes, thus defining a sort of industrial grid of 20x10 km that seems to become the main organizer of territorial systems and of a continuous suburban landscape.

As regards urban development, a centrifugal expansion of sprawl towards peripheries is registered, but in a smaller proportion than during the previous period.

Fig. 96 1840 / Territorial hierachies (source: Steinberg, annex 1; redesigned by the author)

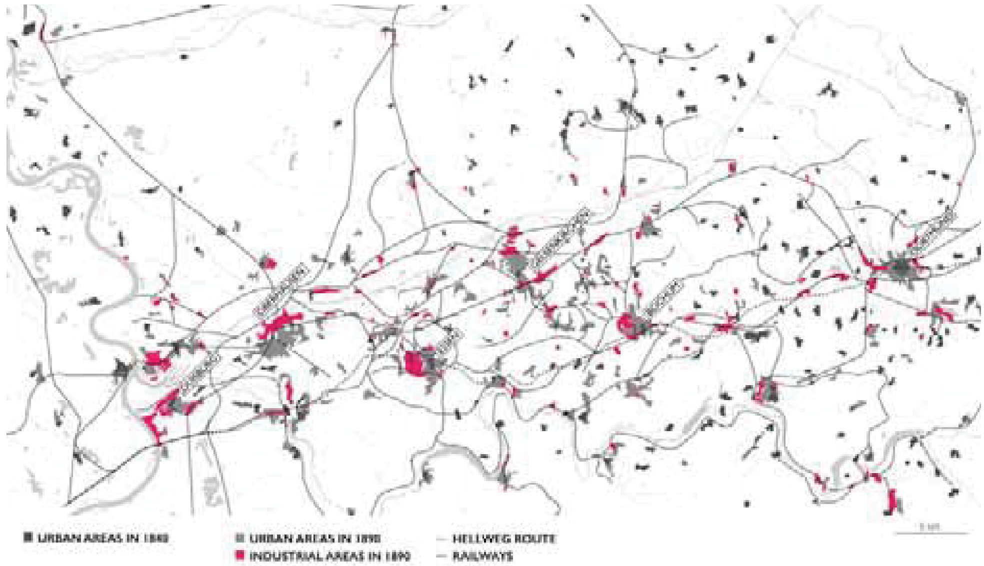


Fig. 97 1840-1890 / Territorial hierachies (source: Steinberg, annex 1; redesigned by the author)

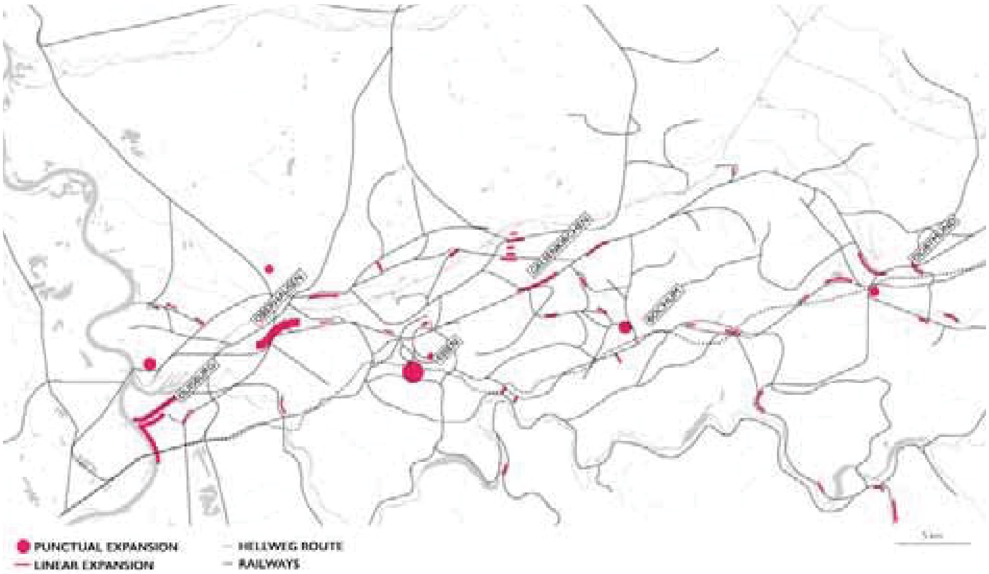


Fig. 98 1840-1890 / Industrial growth trends (source: elaborated by the author)

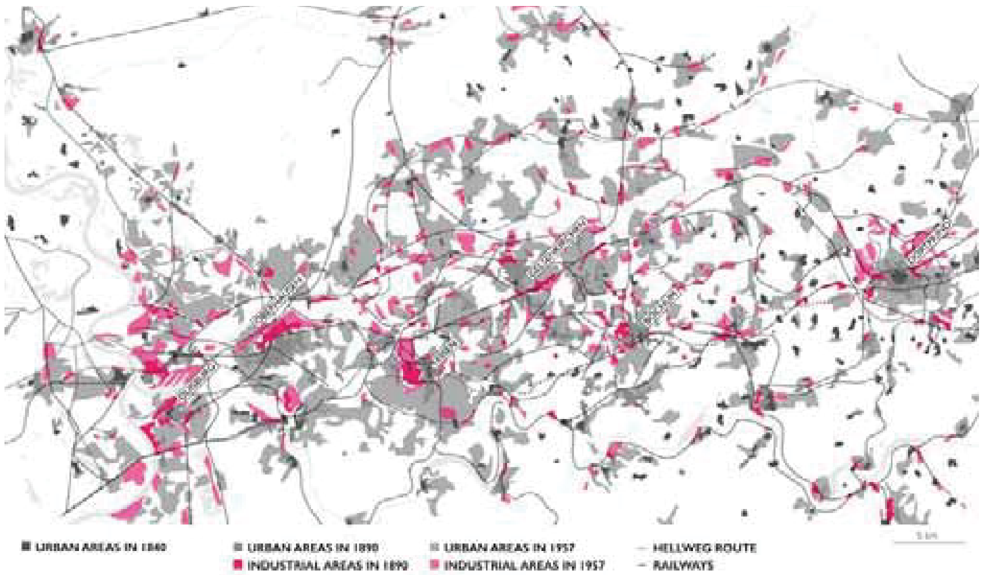


Fig. 99 1890-1957 / Territorial hierachies (source: Steinberg, annex 1; redesigned by the author)

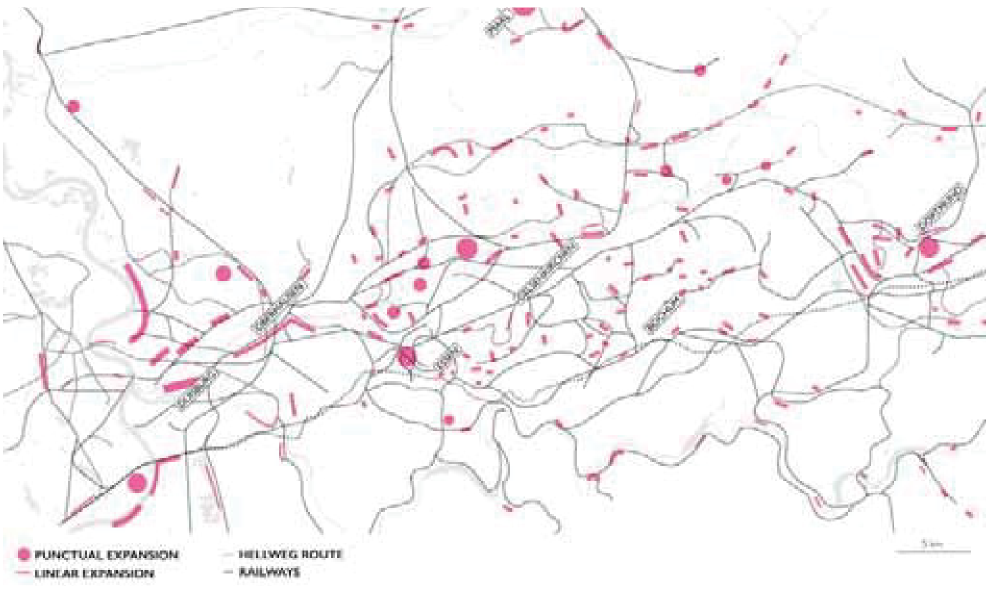


Fig. 100 1890-1957 / Industrial growth trends (source: elaborated by the author)

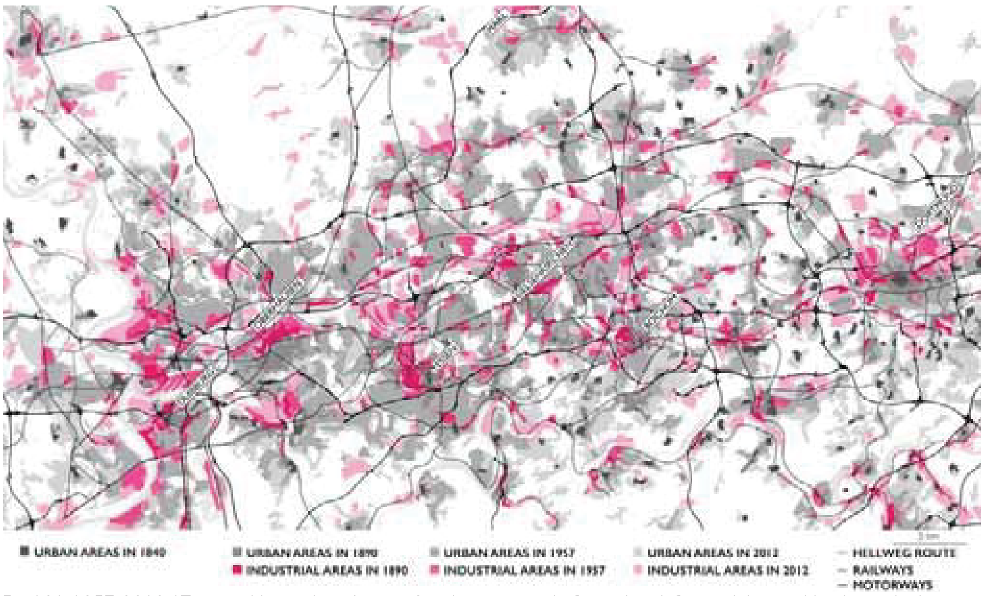


Fig. 101 1957-2012 / Territorial hierarchies (source: Steinberg, annex 1; Corine Land Cover; elaborated by the author)

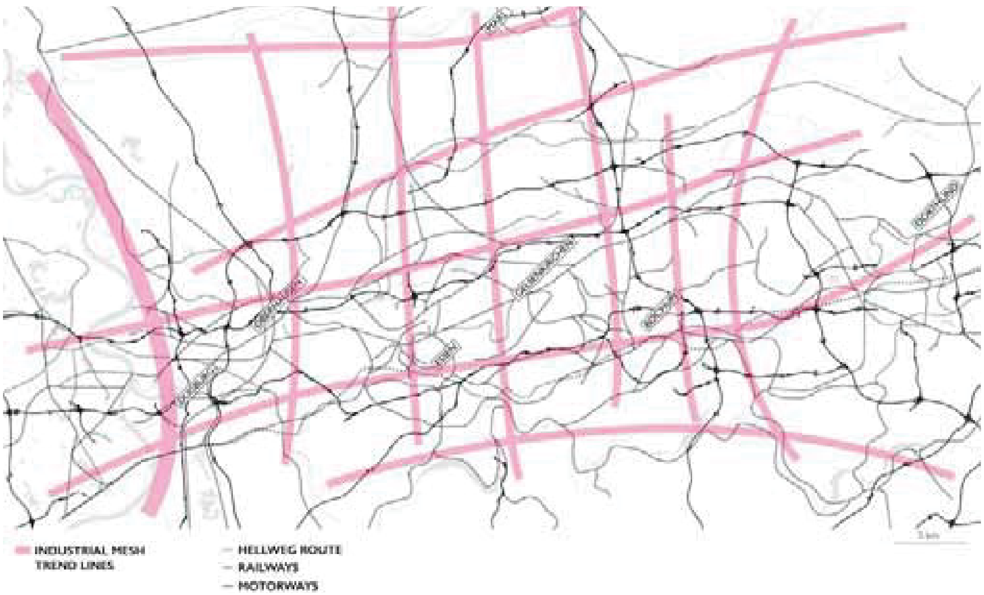


Fig. 102 1957-2012 / Industrial growth trends (source: elaborated by the author)

Fig. 103 Zeche Concordia in Oberhausen, Ruhrgebiet (source: Bernd and Hilla Becher)

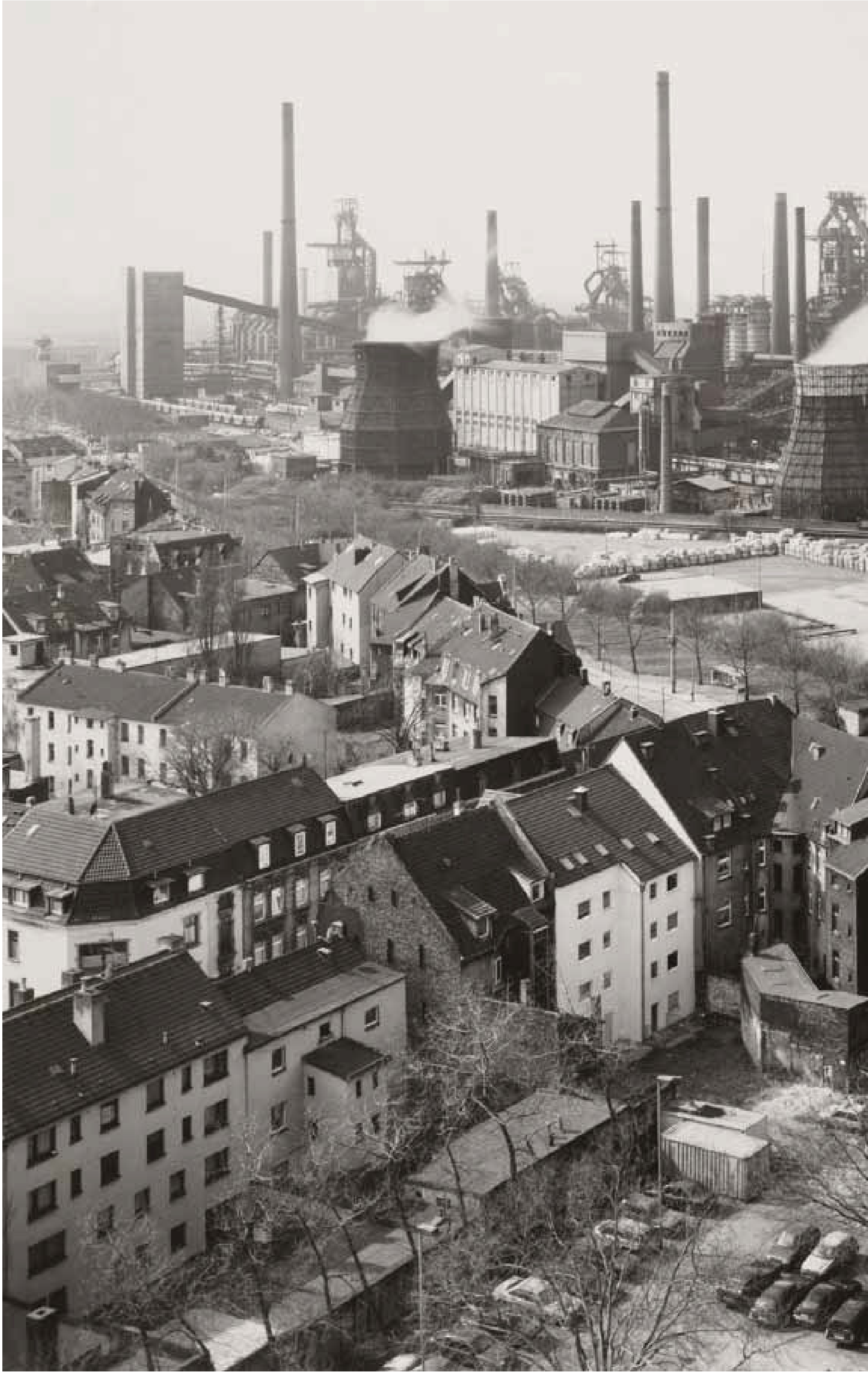
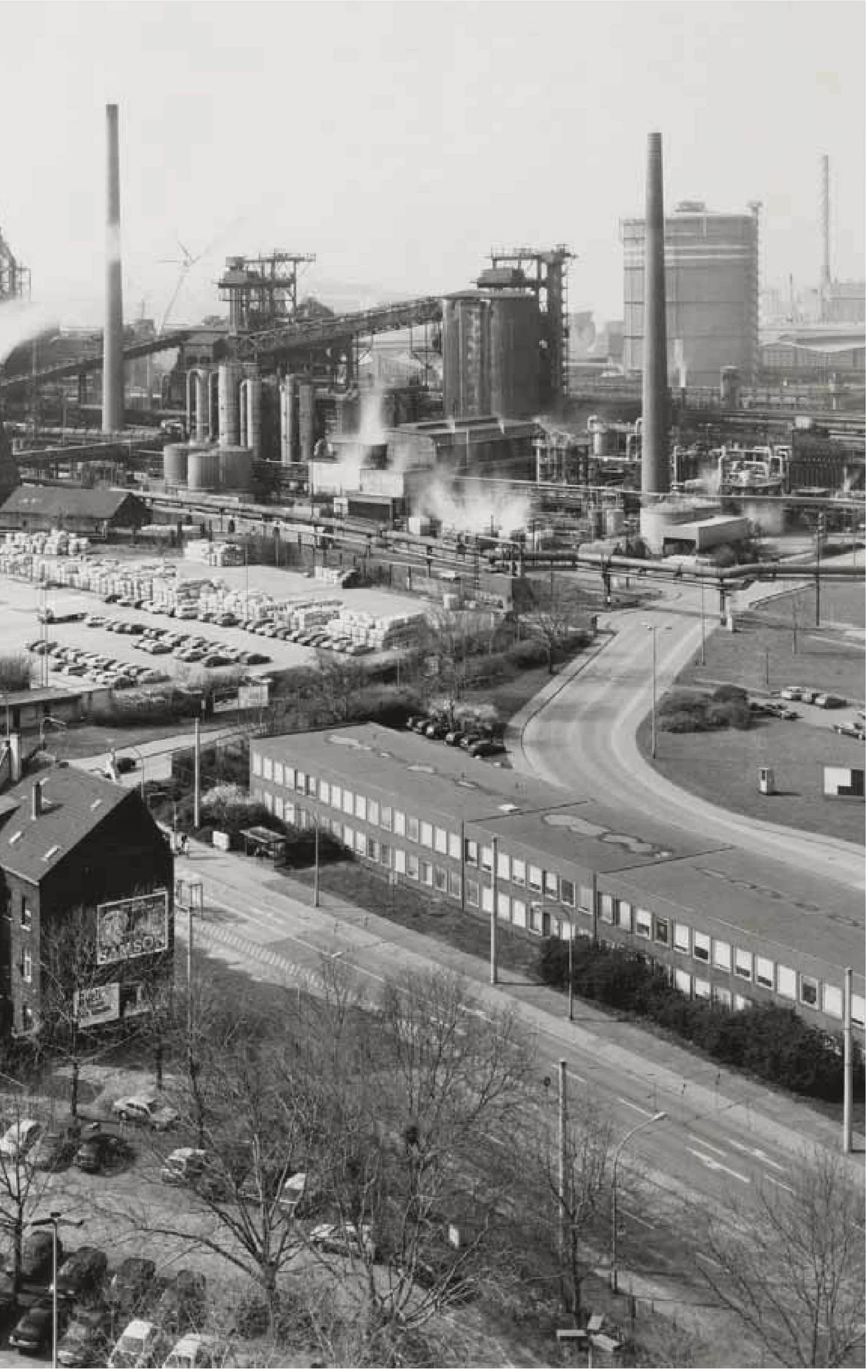


Fig. 104 Duisburg-Bruckhausen, Ruhrgebiet (source: Bernd and Hilla Becher)


SAMSON

Ruhr regional restructuring planning debate at the end of XX century

During the 1980s, the Ruhr region went through the darkest period of its industrialized recent history. Indeed, oil, coal and steel decline, occurred at the end of the 1970s, strongly hit the most important heavy industrialized region of western Europe, leaving dismissed industrial areas and huge territories in catastrophic social and environmental situations. In only fifteen years, from 1970 to 1985, population decreased of approximately 10% (from 5,1 million inhabitants to 4,7 million in 1985), the unemployment rate reached unexpected peaks and no alternative scenarios for a different regional development were imaginable (Uttke et al., 2008). The tight relationship between territories and the coal-based mono-structural economy no longer existed.
Thus, national and local authorities began to question themselves if it was possible to restructure the spatial and economic organization of a region which, for almost one century and a half, exploited territories and their fossil resources at the most.
Due to the social deprivation, the high depopulation rate, the economic problems and the poorness of the polluted environment, in 1988 the state of North Rhine-Westphalia founded an IBA planning company, the International Building Exhibition Emscher Park, to launch a 10-years regional regeneration programme with the intention to reverse the decline focusing on the ecological renewal as the principal engine for a long-term structural and cultural change.
At that moment, three disruptive conditions underpinned such an innovative regeneration programme (Uttke et al., 2008):

- a wide-spreading conscience that a decisive shift towards a c*hange without growth* model was necessary to embrace the values of sustainability and of circular economy;
- Robert Schmidt's large-scale territorial and environmental experience for his *General Housing Estate Plan* (1912), which intended to establish a wide national park among cities in order to achieve a healthy and equilibrate development of industrial areas within living districts;
- the awareness that the industrial heritage which strongly shaped the identity of local communities should not have been erased, but, on the contrary, it should have been preserved and integrated within the regeneration of the regional cultural identity.

New debates appeared on the urban agendas of public authorities, looking for new forms of landscape planning and architecture for the regeneration of the obsolete urban landscape. Concepts as *industrial nature*, *industrial monuments* and *industrial landscapes* emerged from this open dialogue, highlighting how the polluted and industrialized past of the entire region should have been accepted as part of the *territorial palimpsest* (Corboz, 1983) and as a layer which is representative of a very peculiar socio-economic context. In this sense the industrial identity could contribute in the definition of an innovative regional development strategy based on cultural, working, residential and entertainment programmes.

The three above-mentioned concepts deserve to be analyzed more in detail:

- *industrial landscapes* evoke the huge, unplanned, and uncontrolled process of industrialization along the banks of the Rhine, Ruhr and Emscher rivers. Nowadays, the Ruhr metropolitan area looks like an agglomeration of several merged cities, where urban centres, suburbs, industrial architectures, heavy traffic infrastructure, agricultural and natural fragments are included in a unique and disordered urban landscape.
  Starting from this statement, *industrial landscapes* become the testing grounds where to intervene in order to apply a territorial regeneration programme which could bring new job opportunities and unexpected development scenarios;
- the concept of *industrial monuments* focuses on the epochal economic shift occurred in the entire region from industry to culture. Thanks to their architecture, their impressive scale and their industrial charm, some industrial sites monetize their social and cultural role as carriers of an industrial local identity, having been transformed for new cultural uses (museums, auditoriums, etc.). They now constitute a new *industrial cultural heritage* stock which is becoming more and more attractive for touristic offers (see in example the Zeche Zollverein reconversion in Essen);
- the *industrial nature* idea is probably the most radical and disruptive vision, because it considers that *environmental pollution* is richer in biodiversity than an *environmental tabula rasa*. In fact, flora and fauna, during decades, managed to adapt and to live in extreme polluted conditions, naturally regaining possession of dismissed areas. Thus, *industrial nature* represents life that conquers and colonizes industrial derelicts, highlighting the extraordinary resilience and ability of untamed nature to adapt in very arduous living conditions. This means that the diversification of polluted industrial nature in the Ruhrgebiet holds a high biodiversity rate, which often represents a useful tool for soils themselves thanks to its capability to absorb heavy metals (see in example the Landschaftspark Duisburg-Nord by Peter Latz in Duisburg).

In the light of the previous industrial heritage categorization, IBA Emscher Park's actions intended to:

- return nature to the city, linking and regenerating existing open spaces, developing new parks on ancient industrial sites, reconverting ancient railway infrastructure into cycle paths;
- integrate many punctual projects into a connected and coherent vision

of a regional park;

• foster the restructuring of the entire region by proposing a new socio-economic scenario based on an environmental renewal of Ruhr's image and on a *change without growth*, which could create new job opportunities;

• reorganize the industrial landscape of the whole region investing on ecology and culture.

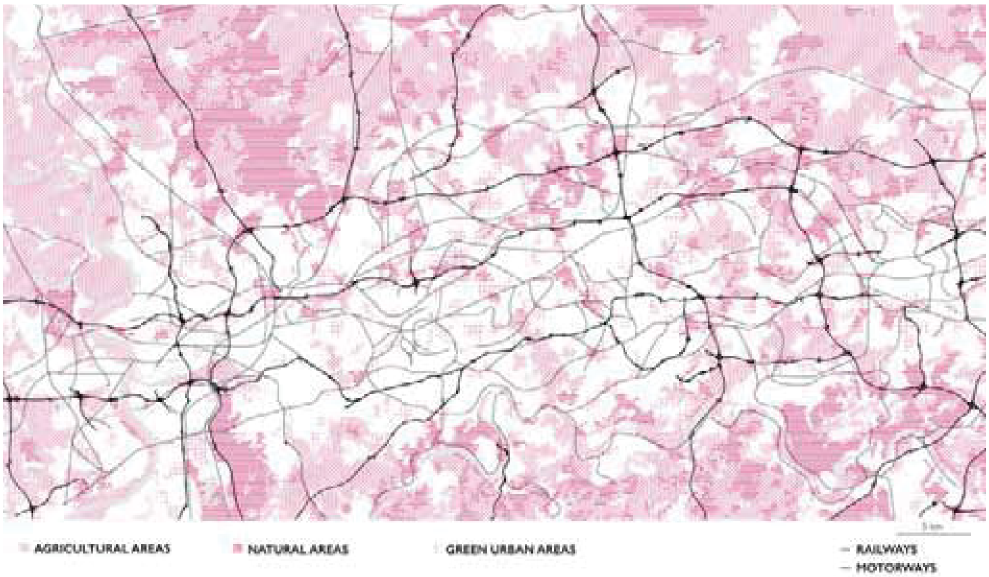


Fig. 105 Unbuilt land uses (source: Corine Land Cover 2012; elaborated by the author)

Not only IBA Emscher Park's territorial strategies were innovative, but even its organizational structure was exemplary. Indeed, IBA Emscher Park was organized as a private subsidiary department of the state of North Rhine-Westphalia. IBA Emscher Park operated, on the one hand, as a collaborative aggregator among cities, institutions, companies and civic initiatives and, on the other one, as a privileged interlocutor with public authorities for planning processes, although its role did not allow to implement autonomous projects. Furthermore, IBA Emscher Park had to guarantee a constant monitoring of procedures, processes and quality of the results.

One of the first operational actions of IBA Emscher Park was to launch a public call for project proposals responding to six principal themes:

• the Emscher Landscape Park;
• the ecological reconstruction of the Emscher river system;
• working in the Park;
• new residential and urban development;
• conservation of industrial monuments and industrial culture;
• new facilities for social, cultural and sport activities.

A pioneering application of Public-Private Partnership financing models supported the implementation of the regeneration programme. In fact, the selected projects were financed up to 40% by private investors, in addition to funding programmes promoted by North Rhine-Westphalia state, the German Federal government and the European Union, which would have approximately covered the remaining 60% of the costs.

It was evident that the 10-year duration programme of the IBA Emscher Park would not have been enough to get the envisaged territorial regeneration, but it should have initiated a territorial development that would have to continue autonomously for at least a generation's lifetime.

In order to guarantee the implementation of IBA Emscher Park's intentions in a longer period, an informal guideline plan for the overall Emscher Landscape Park regeneration vision was drawn up, identifying seven framework plans for the seven regional green spaces along the Emscher river. The potential of the regional park concept became clear to all parties during the 1990s, so in 2001 the state of North Rhine-Westphalia officially commissioned to draw up a regional master plan.

The Emscher Landscape Park Master Plan was concluded in 2006 and defined the strategies to implement portions of the park among the cities.

In 2010, the Emscher Landscape Park Master plan was formally and legally recognized as a supra-territorial planning tool which had to carry out the territorial vision and assigned mandatory responsabilities to the 20 involved cities, in order to guarantee their active involvement in investments for the extension of the park.

Fig. 106 Emscher Landscape Park 2010 (source: metropoleruhr.de)

Fig. 107 Latz+Partner, Landschaft Park Duisburg-Nord, The Railway Park (source: Michael Latz)

Fig. 108 Land srl, Krupp Park, Essen (source: Andreas Kipar, Land srl)

From a cartographical point of view, if we overlap the perimeter of the Emscher Landscape Park Master Plan 2010 on the previous map of the unbuilt land uses, extrapolated from Corine Land Cover 2012 database, it is interesting to notice that the Emscher Landscape Park includes several types of open spaces in order to achieve the envisaged connectivity and continuity of the regional park:

- agricultural and natural fragments, which are embedded in the metropolitan agglomeration, constitute the larger portions of the regional park, and they have to be preserved from any kind of other urban developments;
- the more recent version of the Emscher Landscape Park Master Plan 2010 incorporates some supplementary agrarian areas towards the Lippe river;
- thanks to their proximity to fragile environmental contexts, it is remarkable the crucial role of some industrial areas which act as primary articulators to connect some isolated natural perimeters;
- urban green areas result to be a secondary system which distributes a capillary natural network inside the urban agglomeration, so putting in relation two different scale of open spaces.

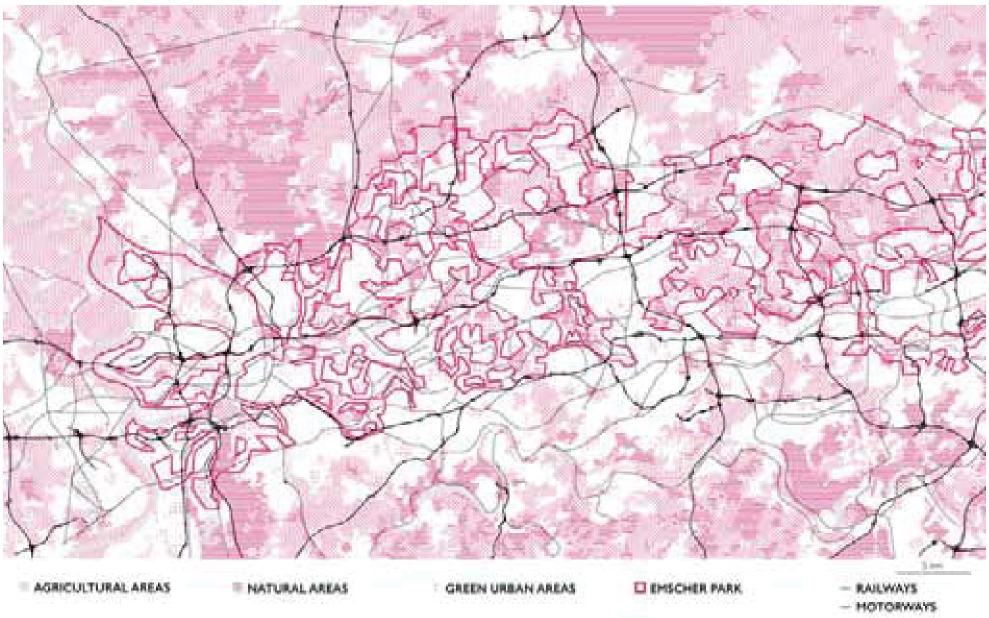


Fig. 109 Emscher Landscape Park land uses (source: Corine Land Cover 2012; elaborated by the author)

AN INDUSTRIAL MESH

The **Industrial Heritage Trail**

Client

Regionalverband Ruhr (Ruhr Regional Association)

Total costs

During the IBA: approx. € 4.3 Mill. of which approx. 20% was invested by RVR, funding from the state of NRW approx. 10% and from the EU approx. 70%; ongoing maintenance of 6 large projects (Century Hall Bochum, hansa Coking Plant Dortmund, North Duisburg Landscape Park, Zollverein Essen, Nordsternpark Gelsenkirchen, Gasometer Oberhausen): € 3.6 Mill. from the state of NRW and € 2.5 Mill. from the RVR

Ankerpunkte
► sind Erlebnisorte und Knotenpunkte für Informationen

Besucherzentrum Ruhr / RUHR.VISITORCENTER Essen und Portal der Industriekultur

ERIH Ankerpunkte
European Route of Industrial Heritage

- ► Landschaftspark Duisburg-Nord
- ► Gasometer Oberhausen
- ► LWL-Industriemuseum Zeche Zollern
- ► UNESCO-Welterbe Zollverein

Bedeutende Siedlungen
► das Ruhrgebiet zu Hause

Für die Sozialgeschichte des Ruhrgebiets und die städtebauliche Gegenwart sind die vielfältigen Siedlungen besonders aufschlussreich. Sie erlauben einen authentischen Einblick in das Leben der Region.

S 1 Flöz Dickebank, Gelsenkirchen
S 2 Dahlhauser Heide, Bochum
S 3 Teutoburgia, Herne
S 4 Alte Kolonie Eving, Dortmund
S 5 Ziethenstraße, Lünen
S 6 Lange Riege, Hagen
S 7 Altenhof II, Essen
S 8 Margarethenhöhe, Essen
S 9 Rheinpreußen, Duisburg
S 10 Alt-Siedlung Friedrich-Heinrich, Kamp-Lintfort
S 11 Eisenheim, Oberhausen
S 12 Gartenstadt Welheim, Bottrop
S 13 Schüngelberg, Gelsenkirchen

Panoramen der Industrielandschaft
► bieten Überblicke

Eine besondere touristische Attraktion bilden die herausragenden Aussichtspunkte einer Region. Hier im Revier kann man die typische industrielle Kulturlandschaft überblicken. Einige dieser Panoramen sind als neue Zeichen der Landmarken-Kunst gestaltet.

P 1 Halde Rheinelbe, Gelsenkirchen
P 2 Tippelsberg, Bochum
P 3 Landschaftspark Hoheward, Herten/Recklinghausen
P 4 Halde Schwerin, Castrop-Rauxel
P 5 Halde Großes Holz, Bergkamen
P 6 Kissinger Höhe, Hamm
P 7 Fernsehturm Florian, Dortmund
P 8 Hohensyburg, Dortmund
P 9 Berger-Denkmal auf dem Hohenstein, Witten
P 10 Tiger & Turtle – Magic Mountain, Duisburg
P 11 Halde Rheinpreußen, Moers
P 12 Halde Pattberg, Moers
P 13 Alsumer Berg, Duisburg
P 14 Halde Haniel, Bottrop/Oberhausen
P 15 Tetraeder, Bottrop
P 16 Halde Rungenberg, Gelsenkirchen
P 17 Halde Schurenbach, Essen

Fig. 110 The Industrial Heritage Trail (source: www.route-industriekultur.de)

A 400 km-long path connects the major industrial heritage of the Ruhr region, which consists in several types of landscapes: industrial sites, workers' housing estates, museums, panoramic views and natural areas. The idea of the Industrial Heritage Trail, developed during the 1990s as part of the IBA Emscher Park, extended towards the entire Ruhr region. Twenty-five thematic routes accompany visitors to deepen the most important aspects of the Ruhr industrial culture, such as mining techniques, workers' lifestyle, railway network development. The richness of the touristic offer made the Industrial Heritage Trail the most important infrastructure of the Emscher Landscape Park.
What is outstanding is the interest that this kind of approach aroused in other countries, leading to the constitution of a European Route of Industrial Heritage (ERIH) which counts over 830 locations in 29 European countries.

Fig. 111 Halde Grosses Holz (source: RIK / Guntram Walter)

Fig. 112 Zollverein Essen (source: RIK / Michael Gohl)

Fig. 113 Das UNESCO Zollverein, Essen (source: RIK / Sascha Kreklau)

Fig. 114 Ziethenstrasse (source: RIK / Guntram Walter)

Fig. 115 Dahlhauser Heide (source: RIK / Guntram Walter)

THE INDUSTRIAL CULTURAL LANDSCAPE

The **Zollverein Coal Mine & Coking Plant** reconversion (Essen)

Client

Landesentwicklungsgesellschaft (NRW regional Development Society)

Project team

Zollverein masterplan: OMA Rem Koolhaas (Rotterdam)
Kesselhaus (boiler plant) conversion: Foster Associates (London)
Kohlenwäsche (coal-cleaning plant): OMA Rem Koolhaas (Rotterdam)
Zollverein School of Management and Design: Kazuyo Sejima + Ryue Nishizawa (SANAA) (Tokyo)
Zollverein Industrial Landscape: Agence Ter (Paris/Karlsruhe)
Zollverein Coking plant conversion: Jürg Steiner (Berlin) and Heinrich Böll (Essen)

Total costs

Shaft XII Coal Mine:
Costs during the IBA Emscher park (incl. hall renovation and conversion, heritage route layout, costs of developing Zollverein Park): about € 64 Mill; costs and total public investment in follow-up projects after the IBA: € 145.6 Mill. (incl. for Entry project, knock-on financing and construction of the new Zollverein School, establishing the Ruhr Museum, coal-cleaning plant and Hall 18 turnaround hall conversion, business park design, Zollverein PArk)
Coking Plant:
Securing and converting the Kokerei Zollverein for the IBA finale: € 6.65 Mill. (public funding), solar power plant: 1st construction phase 1999: € 1.14 Mill., of which € 55'000 donations, 2nd construction phase (2000-2001): € 0.7 Mill., of which € 206'000 donations and € 165'000 capital from Stiftung für Industriedenkmalpflege und Geschichtskultur

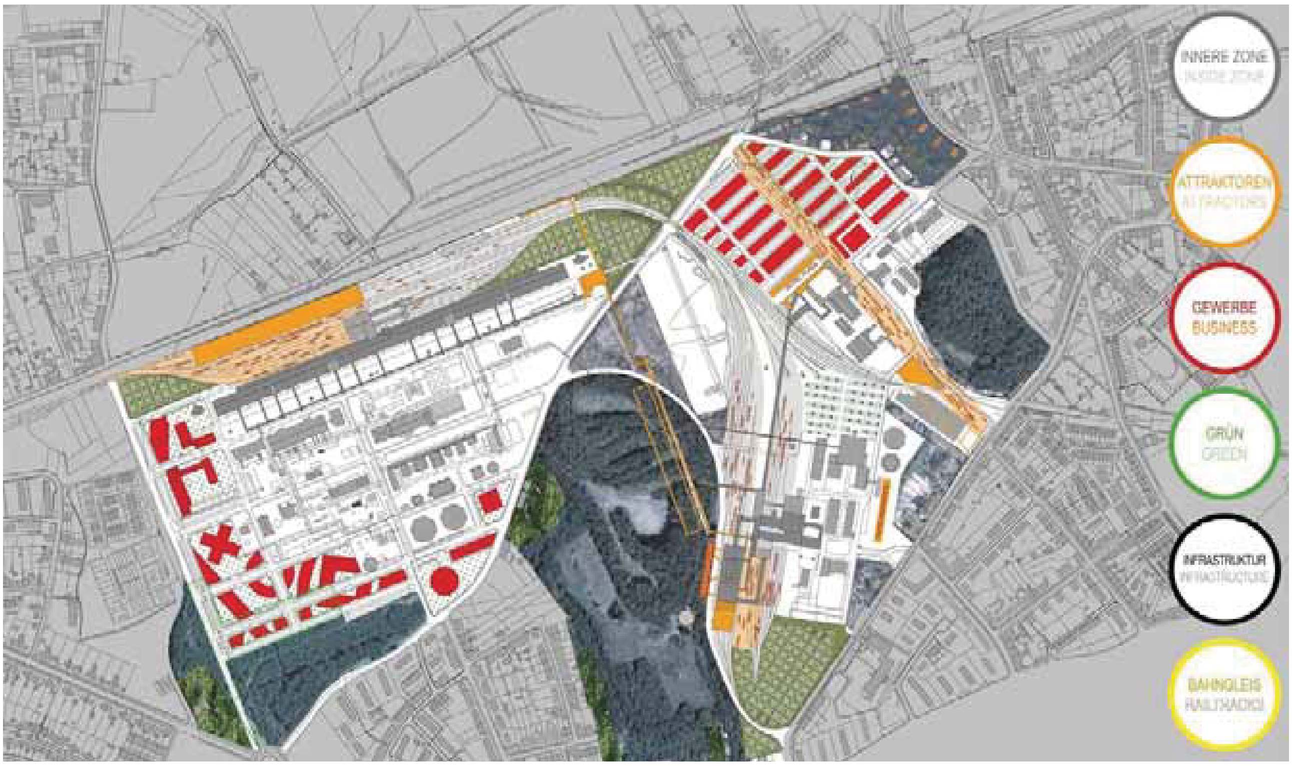


Fig. 116 Zollverein master plan (source: OMA)

Zollverein was worlwide renowned for having been the most productive coal mine in the first half of the XX century. In addition, the industrial architecture of the coal mine Shaft XII designed by Fritz Schupp and Martin Kremmer in Bauhaus style, dating back to 1928, is still recognized as a remarkable expression of rationalism. Since 2001 Zollverein site has been inserted in the UNESCO World Heritage Site list as a *Cultural Landscape* due to its material and immaterial legacies of the coal-based industrial culture.
After its shut-down in 1986, the reconversion project of the entire area for touristic purposes was integrated in the IBA Emscher Park in order to conserve, renovate and reuse the existing industrial heritage.
The coal mine turned into a lively business and tourism location with a strong design and arts focus and became one of the main important hubs of the Emscher Landscape Park and of the Industrial Heritage Trail.
Thanks to OMA - Rem Koolhaas' project for the conversion of the coal-cleaning plant in the regional Ruhr Museum, Zollverein coal mine site became the access point for thousands of visitors to understand the fascinating history and territorial transformations of one of the largest industrial regions of the world, starting from the origin of the coal formation 300 million years ago to the Ruhr coalfield agglomeration.
In order to witness the structural shift from a productive region to a tertiary economy, other worldwide renowned architects participated in the revamping of the image of the area. The new Zollverein School of Management and Design building, a 35x35x35 m cube designed by SANAA, symbolizes the intentions of the regeneration programme to invest in culture and in arts as a primary engine for new investments.
New functions were also foreseen for the reconversion of the coking plant. In order to valorize the grandeur of coal infrastructures, some temporary leisure and sport activities have been integrated in the very middle of highly technological landscapes, such as the pool on the top of two shipping containers and the skating rink in front of the coke ovens.
The industrial monuments are immersed in a widespread nature resulting from industrialization developments. The Industrial Landscape Masterplan designed by Agence Ter integrates the existing industrial forests and lawns to a system of pedestrian and bike pathways which retrace the ancient railway tracks and which is connected to the wider Emscher Park bike path.

Fig. 117 Entrance to the Ruhr Museum realized by OMA (source: Anselm Van Sintfliet)

Fig. 118 Zollverein School of Management and Design realized by SANAA (source: Thomas Willemsen)

Fig. 119 Pool in Kokerei plant (source: Jochen Tack)

Fig. 120 Zollverein Park realized by OMA and Agence Ter (source: Amalie Wright)

THE ACCEPTANCE OF A HISTORICAL CONTAMINATION

The **Landscape Park Duisburg-Nord**, a project of the International Building Exhibition Emscher Park (IBA)

Client

Landesentwicklungsgesellschaft Nordrhein-Westfalen
LEG NRW als Treuhänder des Stadt Duisburg
Gartenamt und Planungsamt der Stadt Duisburg

Project team

Latz + partner, Kranzberg/Duisburg

Total area

230 hectares

Competition

International cooperative competition 1990
Main planning and realization phase: 1991-1999

Total costs

During the IBA approx. € 50 Mill, follow-up costs, annual requirements: € 4 Mill of which € 2.6 Mill. in grants from the city of Duisburg, Regionalverband Ruhr 8Ruhr Regional Association) and the state of Nordrhein-Westfalen

Financing

financed by different promotion programmes: Ecological programmes Emscher-Lippe, Urban Promotion Programme, Skeleton of Action for Coal Mining Areas

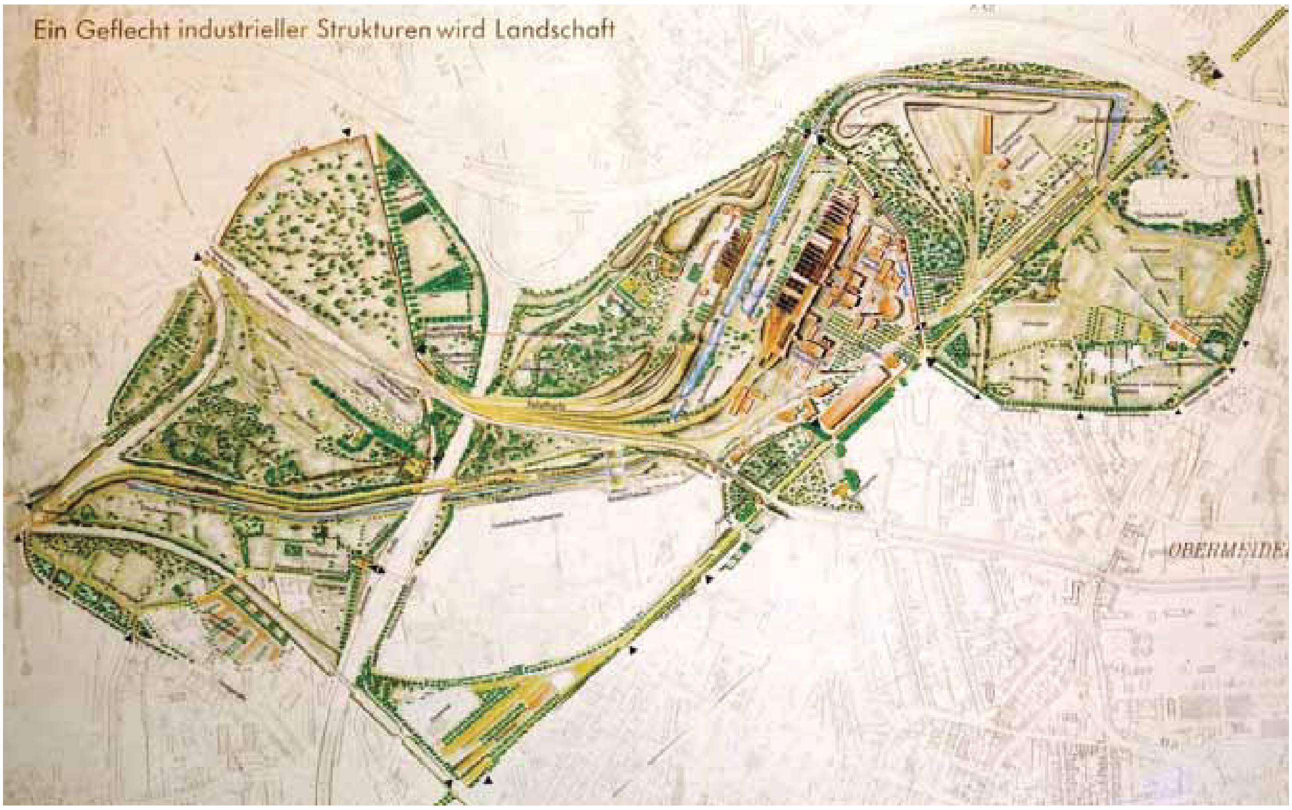


Fig. 121 Landschaft Park Duisburg-Nord, Masterplan (source: Latz+Partners)

After 82 years of operation, the Thyssen blast furnace plant in Duisburg-Meiderich shut down in 1985. The polluted environment left behind the dismission of that huge steel industry was representative of the socio-economic crisis that the Ruhr region was going through.
In 1989, the proposal supported by the city of Duisburg to reconvert over 200 hectares of an abandoned heavy industrial area into a landscape park as part of the IBA Emscher Park represented an innovative approach to deal with the reconversion of industrial sites. The landscape architectural competition was won, in 1990, by Latz + Partners. Their proposal radically explored the limits of settling a landscape park in a similar context. In fact, the question that Peter Latz wanted to answer through the project was: do industrial cultural landscapes have to be restored by means of a natural romantic approach or do they have to be accepted with their poor physical qualities in order to be interpreted through a new syntax?
Industrial memory and *ecological stabilization* are the two concepts on which the project lies:
• the old industrial traces constitute the primary expression of a regional cultural identity which dates back to one century and half. The historicization of the memory of the industrial artifacts becomes an important leverage on which rooting a future landscape park. Thus, the ancient steel production is symbolically valorized in the principal open space, the so called *Piazza Metallica*, where recreative activities, exhibitions, concerts take place for the community. Moreover, an innovative recycling strategy of the existing industrial structures for leisure and sports activities (diving silos, climbing chimneys etc.) wants to avoid any rigid and conventional use, preferring flexible, temporary and alternative ways of utilization to valorize the industrial memory;
• for ecological stabilization, Latz means that the acceptance of contaminated physical qualities of industrial sites is necessary. A contaminated environment is still a biodiversity reserve, where several flora and fauna species adapted themselves to live in extreme conditions. A *tabula rasa* approach, consisting in the total removal of polluted soils for an off-site treatment or in their burial under thick layers of clay, would reduce the biodiversity rate and would not solve the contamination problem at all. Thus, an on-site bio-soil remediation, articulated over the course of several decades, is proposed by means of a slight gas diffusion which results in a slow reduction of contamination. The reclamation costs are inferior if compared to standard invasive techniques, the biodiversity of contaminated environments is preserved and contributes to a natural remediation process. A limited use (such as only for cycling and walking) is temporarily foreseen for those contaminated areas that, at the moment, cannot accept a permanent presence of human activities.

Fig. 122 Landschaft Park Duisburg-Nord, Piazza Metallica (source: Latz+Partners)

Fig. 123 Landschaft Park Duisburg-Nord, The Sinter Park (source: Latz+Partners)

Fig. 124 Landschaft Park Duisburg-Nord, The Waterpark (source: Latz+Partners)

Fig. 125 Latz+Partner, Landschaft Park Duisburg-Nord, The railway park (source: Latz+Partners)

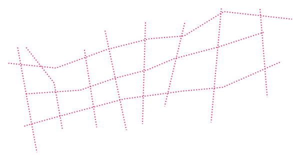
A cartographical analysis of two polycentric models

The historical analysis presented in the previous paragraph highlighted how the industrialization of the first industrial revolution and its tight bond with the availability of energy resources in the subsoil generated an eccentric and peripheral urban development, consolidating a dense polycentric territorial structure.

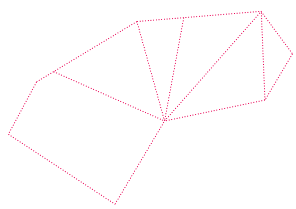
comparative analysis and benchmark

If these considerations are valid for the Ruhr region, representative of the first industrial revolution's settlement logic, we would like to understand the territorial legacies of a very different polycentric case study, which, at the beginning of the XX century, witnessed the advent of the second industrial revolution through the establishment of oil-based industrial activities: the *central Veneto region* in Italy. While the Ruhr case study has been deepened through a chronological analysis of territorial transformations using historical literature texts, the intent of this paragraph is to try to use another territorial analysis' point of view to discern the different polycentric territorial hierarchies. In fact, the paragraph will be structured through a comparative cartographic analysis of some GIS thematic maps in their current territorial configurations. If for the *Ruhr* case study we will resume the most important key elements discussed in the previous historical analysis so as to define a territorial benchmark, for the *central Veneto region* cartographies will be used as a support for a more extensive theoretical reorganization of some important contributions, which are part of urban and economic literatures.

industrialization process



As already seen before, the Ruhr region experienced several industrialization trends, in particular during the coal era. Territories witnessed an independent urban growth around peripheral industrial poles which stood in proximity of coal mines, until suburbs merged into a continuous urban agglomeration, incorporating the historical centers, which did not represent the center of gravity at any time. From a regional point of view, the resulting continuous industrial macro-grid of about 20x10 km seem to be a territorial organizing factor.



In order to contextualize the temporality of the industrialization process occurred in the two case studies, it is important to emphasize that in about one hundred years (1850-1970) while the Ruhr region was facing the peak and the decline of an economy rooted on a coal-based industrialization, Veneto region had not been touched by any massive industrial revolution yet. Indeed, according to Roverato (2008) and Bagnasco (1977), a long and dispersed industrialization process, based on the consolidation of some industrial districts constituted of small-medium enterprises and operating around small urban centres, began to take root in the region from the end of the XIX century. This phenomenon gave rise to what Bagnasco called "la terza Italia" (translated in English as "the third Italy"), highlighting an alternative territorial development model which differed from the usual dichotomy between the north-western Italian massive industrialization and the agricultural backwardness of the south. In fact, until the 1960s Veneto was considered as an agricultural and underdeveloped region, "the south of northern Italy" (Roverato, 2008, english translation) and, during the first half of the XX century, it was believed that some special laws to settle innovative industrial sectors were necessary to boost the economic development of those apparently depressed areas. In fact, the richness of the spontaneous and diffuse small-medium industrial pattern was a quite invisible process and was not perceived by the politics of the time as a real industrialization phenomenon. Thus, Veneto region was characterized by two independent infrastructural and industrial policies, which acted at different scales and with different scopes:

- "large public works" where envisaged at a national level in order to insert Veneto region in a wider European market;
- an "incremental, spontaneous and bottom-up process" of minute interventions on infrastructure and industrial activities involved large territorial portions, supporting the settlements' dispersion phenomenon and leading to its consolidation and densification (Tosi, Munarin, 2001).

Until the 1960s, two have been the principal industrial concentration experiences in the central Veneto region, which not resulted from the spontaneous evolution of the already existing small-medium industrial districts, namely:

- *Porto Marghera industrial harbour*: the project to move port activities from Porto della Marittima, lying on Venice island, to the mainland, in the Bottenighi area, near Mestre transit area, dates back to the first decade of the XX century, when the Law 542/1907 allocated some funds for the realization of the logistic harbour (Porchia, 2012). If the first oil activities in the *Porticciolo dei Petroli* go back to the 1920s when oil tankers arrived from Italian colonies full of crude oil, the idea to couple a technically advanced industrial pole predominantly in the electrochemical, electrometallurgical and petrochemical sectors dates back to 1935;
- *ZIP Padova*: in 1946 the proposal of the Chamber of commerce, industry, crafts and agriculture to settle an industrial platform and an interport in the south-eastern outskirts of Padua responded to the intent to provide the underdeveloped Veneto region with the necessary logistic infrastructure to enhance a tardive industrialization process. In 1955 the logistic and industrial area was inserted in the General Regulator Plan of the city[1].

1 To have a general view of the main storic events of the ZIP Padua, you can consult the synthetic section on http://www2.zip.padova.it/zip3.htm#storia1900

Once the dual scale of industrial sector in central Veneto region has been introduced, it is interesting to try to interpret the role and the fallout that investments in concentrated industrial poles had in the consolidation of a decentralized and diffuse pattern of small-medium enterprises. According to Tosi and Munarin (2001), four are the possible hypothesis:

- big industries settled in Porto Marghera probably played an important role as "incubators of entrepreneurial skills", so enhancing the emergence of professional figures that, after having been simple workers within the big industry, would have started their own business in the territories of the dispersion. They brought their professional activity closer to their main social institution, the family-home, and contributed in a process of decentralization of experiences and know-how;
- the presence of a highly technological production, such as for the plastic in the petrochemical district in Porto Marghera, boosted the development of new industrial districts which looked for innovative products (i.e. ski boots district in Montebelluna);
- massive industrial processes would have boosted the decentralizaed production, because new productive sectors were required by the big industry in Porto Marghera, and small-medum enterprises were fostered to grow and to innovate processes and productions;
- the centralized industrial events in Porto Marghera are unrelated to the development of the small-medium productive system, as the latter has its origins in other economic and territorial values, such as in an entrepreneurial attitude of the middle-class, in tax incentives for the settlement of small-medium production activities and in the spread of new productive activities far from the major industrial poles, but close to proto-industrial settlements (Roverato, 1996).

The debate around the relationship between the few concentrated industrial poles and the diffused local productive pattern remains open and, in our opinion, each of them has contributed in establishing peculiar territorial hierarchies. In any case, it seems evident that the two industrial development models no longer established any type of physical and geographic dependency with the availability of energy sources in the subsoil.

To sum it up, the industrialization process occurred in the central Veneto region showed three principal settlement trends which can be chronologically recognizable as follows:

- a primordial *scattered settlement* of small-size industrial buildings along roads connecting medium-size urban centers, indistinctly mixed with the residential fabric. The characteristic dispersion of industrial buildings within Veneto countryside landscape has also been supported by the

Regional Law n.73/1978, according to which the expansion of existing productive activities in agricultural areas is recognized as a fragmented territorial identity;

• until the 1960s, we witness the appearance of few concentrated *industrial poles* close to major urban centers and along principal railway and motorway axes in order to be connected with national and international markets;

• from the 1990s, we observe the consolditation of *industrial platforms*, that is to say single-use industrial enclaves. They are situated in proximity of small towns in the central plain and recognized as a new planning instrument by the Regional Law n. 11/1987, which requires municipalities to adopt urban zoning variations in order to group productive settlements in apposite sites.

The current legal framework imposing *industrial platforms* greatly reduced local entrepreneurial spontaneity, because a unitary industrial project and the mobilization of larger capital are required.

At present, the diffused Veneto industrial model seems to be in crisis, thus, according to De Rita and Galdo (2001), the roles of industrial concentrations and of local productive settlements can be reshaped: major industrial centres should host research centres and business incubation programmes in order to support the productive dynamism of the small-medium industrial pattern.

Fig. 126 Industrialization in the Ruhr region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)

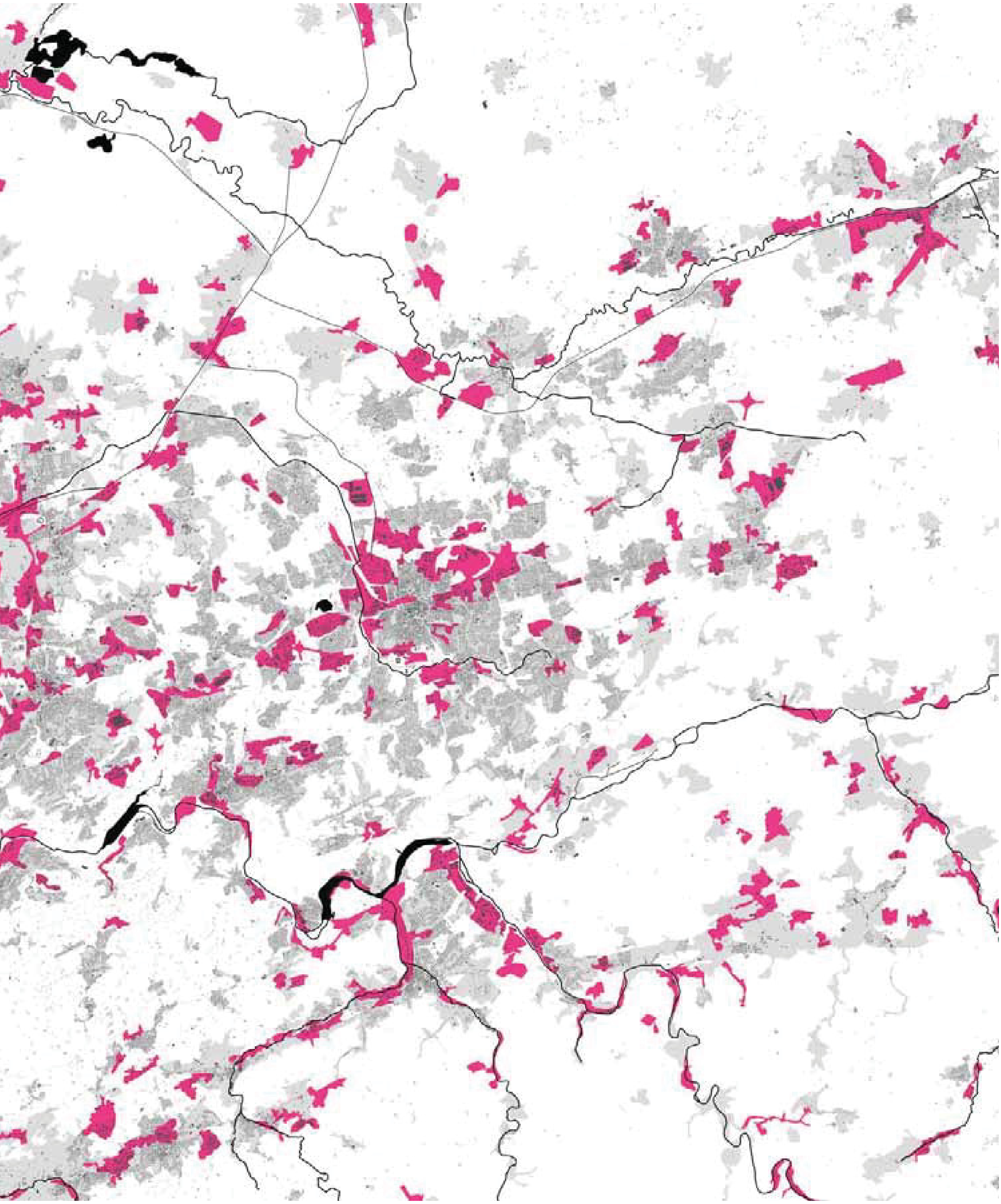


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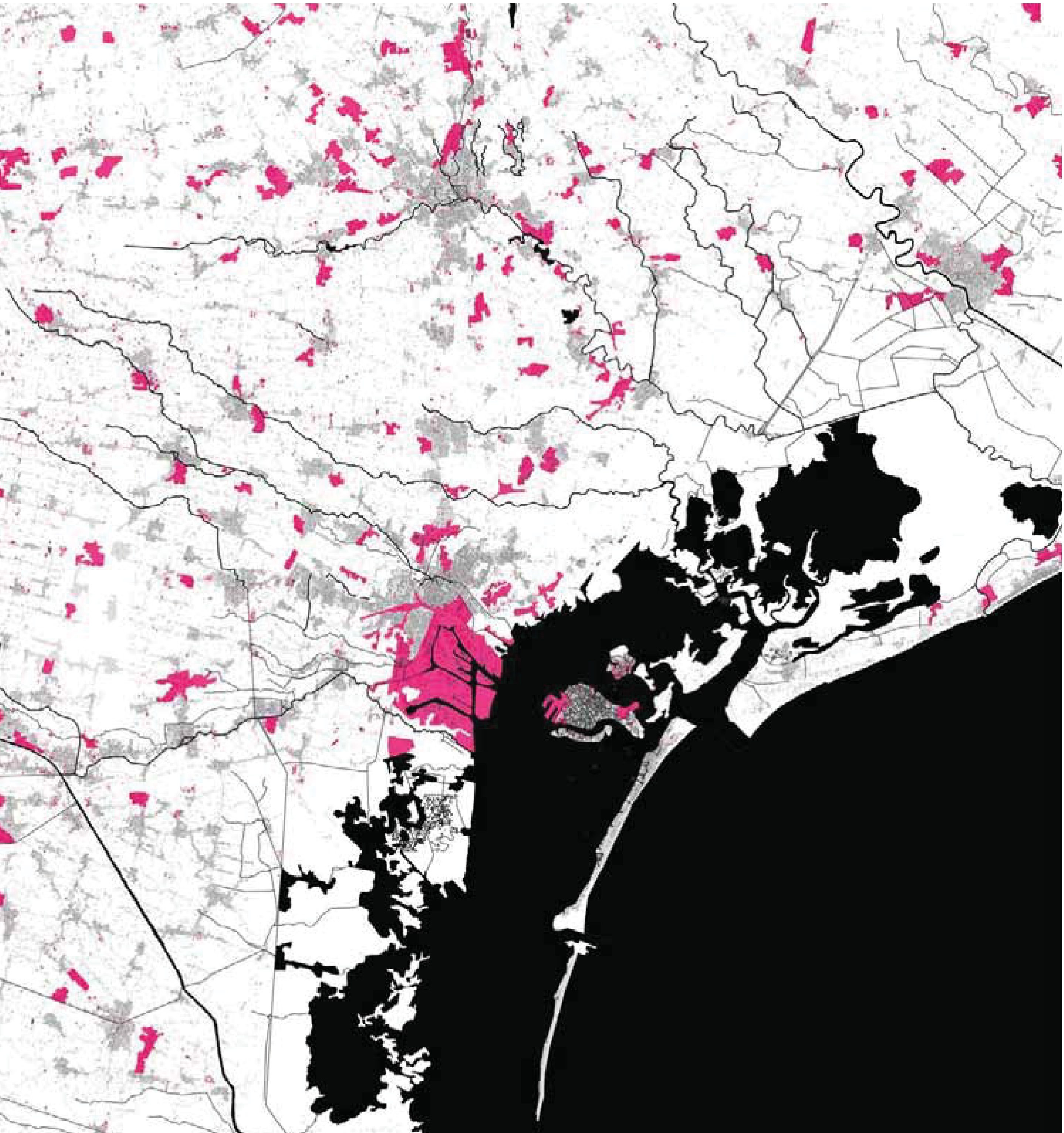
Fig. 127 Industrialization in the central Veneto region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)



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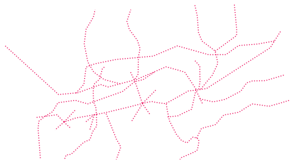
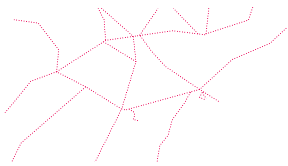
industrialization and railway infrastructure



In the second half of the XIX century, due to the lack of a national and regional railway infrastructure planning, private companies controlled the construction of a profit-oriented railway network for goods and raw materials transport, in order to connect coal mining sites to heavy industrial plants or to logistic harbours along the river Rhine (Reulecke, 1984). If during the first regional industrialization period railway infrastructure reinforced the role of the existing urban poles along the Hellweg trading route, during the second one a principal East-West oriented railway axis parallel to river Emscher became the principal backbone along which the sparsely inhabited territories settled up their urban and industrial growth. Only at the beginning of the XX century, with the nationalization of the existing railway network, rail infrastructure began to be used even for passenger transport (Hötker, 1988). This circumstance contributed in the diffusion of the *garden city* as the principal workers' dwellings model, so connecting residential areas with working sites, recreational areas and city centres by public transports. It is remarkable how the tardive industrial development along the river Lippe, occurred only after the World War II and the shift towards the oil-based second industrial revolution, completely lacks of a dense railway network.



If we look at the central Veneto situation in the mid-nineteenth, and even more in general at the Italian territory, rail infrastructure had a planned development defined by State policy decisions. When the first railways appeared on the Italian territory (in 1839 Naples-Portici and in 1840 Milan-Monza), Italy was still in a very fragmented political situation. After the Italian unification proclaimed in 1861, the spread of rail infrastructure was promoted by principal Italian politics as an unmissable opportunity to enhance the industrialization process and to physically and metaphorically connect territories that, until a short time before, were separate and distant (Sellari, 2011). The economic union of the recent Italian kingdom, on the style of the German *Zollverein,* that is to say the customs unification occurred in 1834, would have passed through an ordered railway network[2]. From 1865 to 1885, Italian territories witnessed a maximum effort in building new railways intending to develop a principal East-West connection from Torino to Trieste, two main coastal lines, the Tyrrhenian and Adriatic axis, which would have touched the main Italian ports, and a series of secondary lines that would have branched inwards.

In the Lombardy-Veneto Kingdom, the construction of the Milan-Venice line began in 1841, but was accomplished only in March 1878 after the unification of the Italian kingdom. At that moment, northern Italy was not yet interested by a massive industrialization process like elsewhere in northern Europe. Thus, the railway network was the result of a general infrastructural planning for passenger

2 Petitti, I, (1845) *Delle strade ferrate italiane e del miglior ordinamento di esse*, Capolago.

accessibility, goods supplying and mostly military purposes. In fact, even for the decisive battles in north-western and north-eastern Italy to get rid of Austrian domination, railways played a strategic role in transporting troops (Sellari, 2011). The fragmented political situation of pre-unitary Italy led to having to mend, during the post-unification period, the already built railway branches and to manage, from an administrative point of view, the difficulties due to the presence of several private operators (twenty-two at the time of the Italian unification), until the statalization of rail infrastructure which took place in 1905.
It is interesting to underline that, since the end of the XIX century, Italy was at the forefront in the search for technical solutions for the electrification of the rail network, in order to become completely independent from the importation of coal from abroad.
The current railway network seems to confirm the original hierarchies imagined at the end of the XIX century. If we look at a recent map available on the website of the major Italian operator *Ferrovie dello Stato Italiane,* the main axis are still the East-West line towards Venice and the North-South Adriatic coastline. Secondary connections go inward through a well-developed triangulation of connections between medium-sized centers, but they cannot establish adequate connections with the manyfold small towns which scatter the territory.

Fig. 128 Veneto railways network (source: Ferrovie dello Stato Italiane)

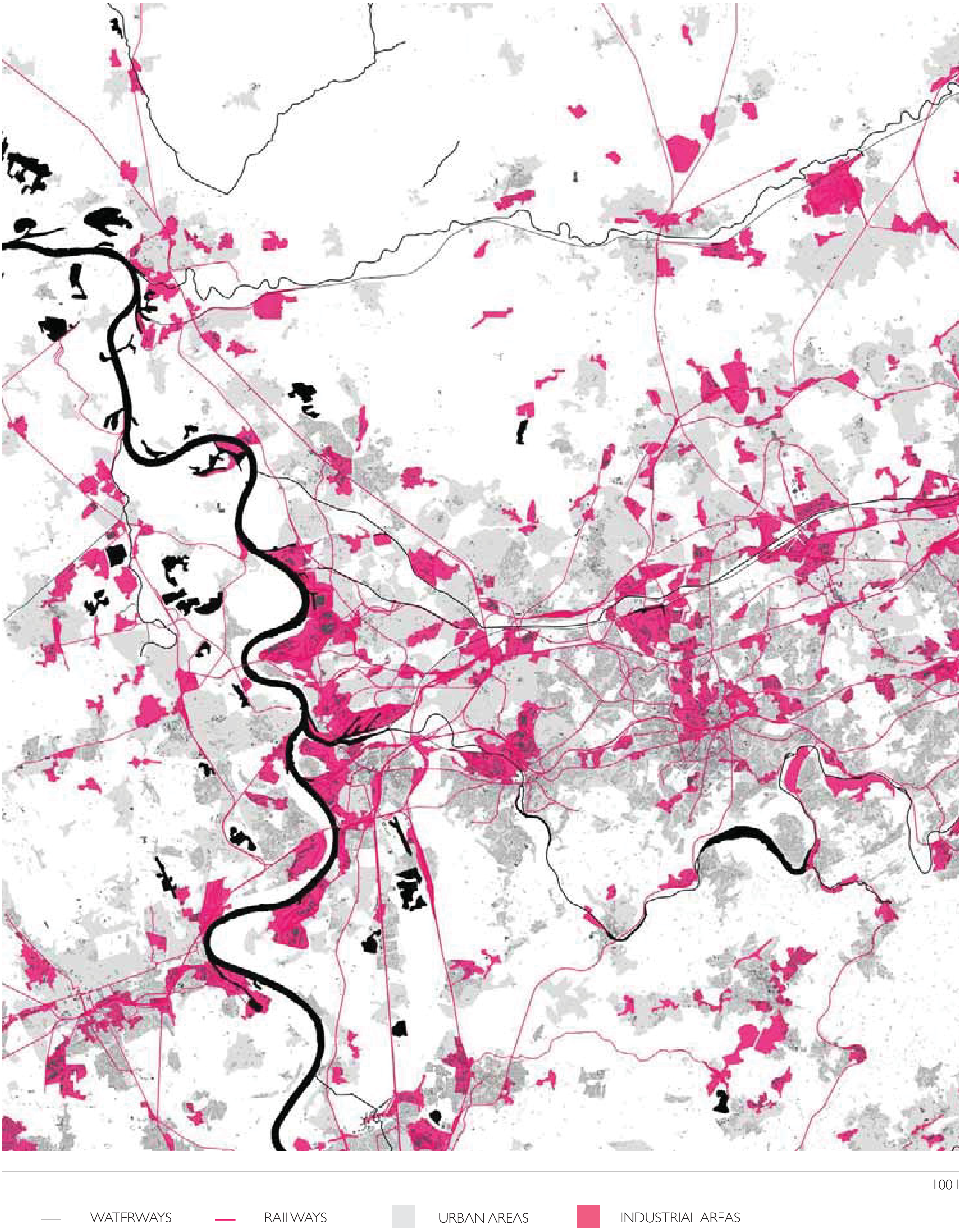


Fig. 129 Industrialization and railway network in the Ruhr region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)

km

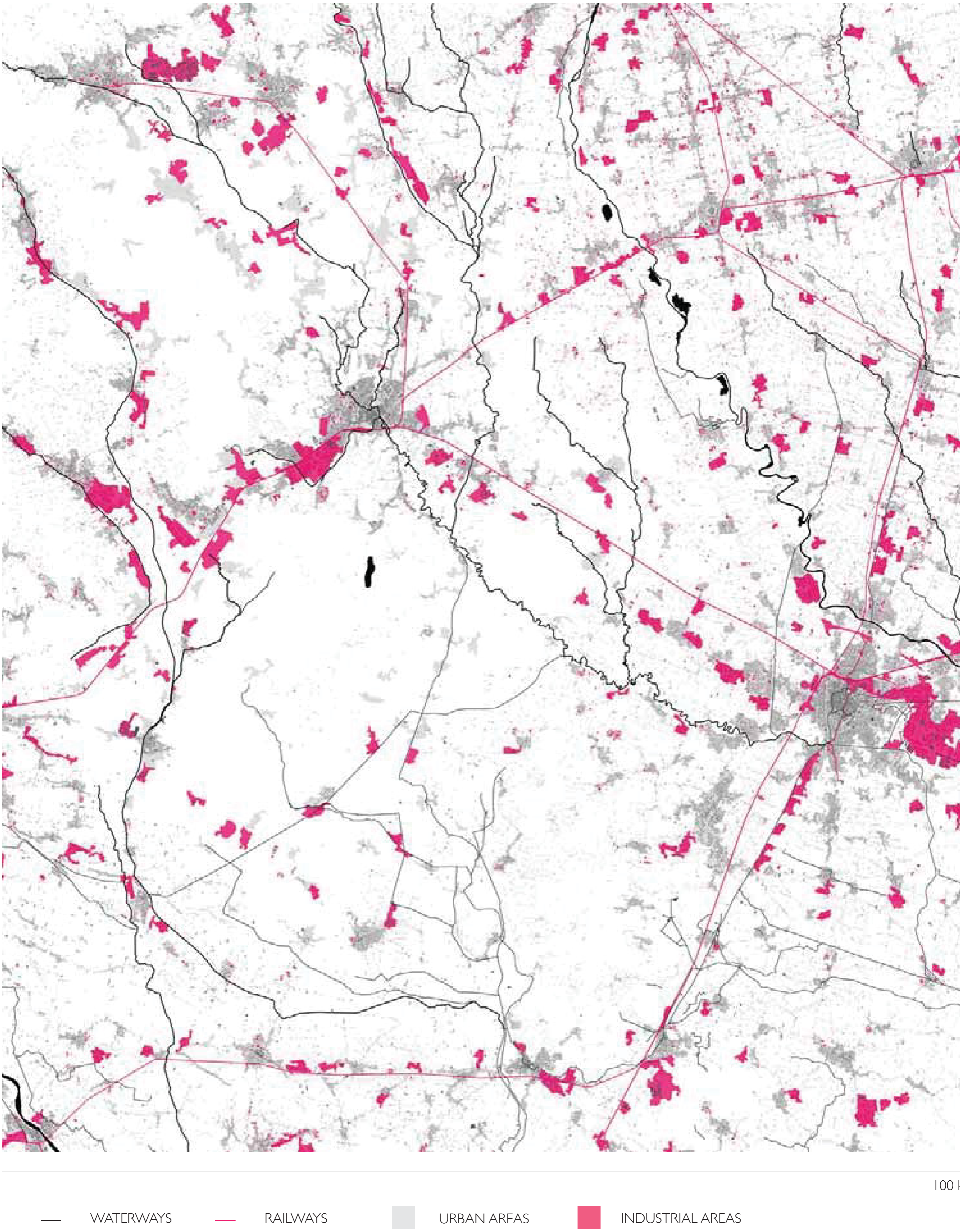
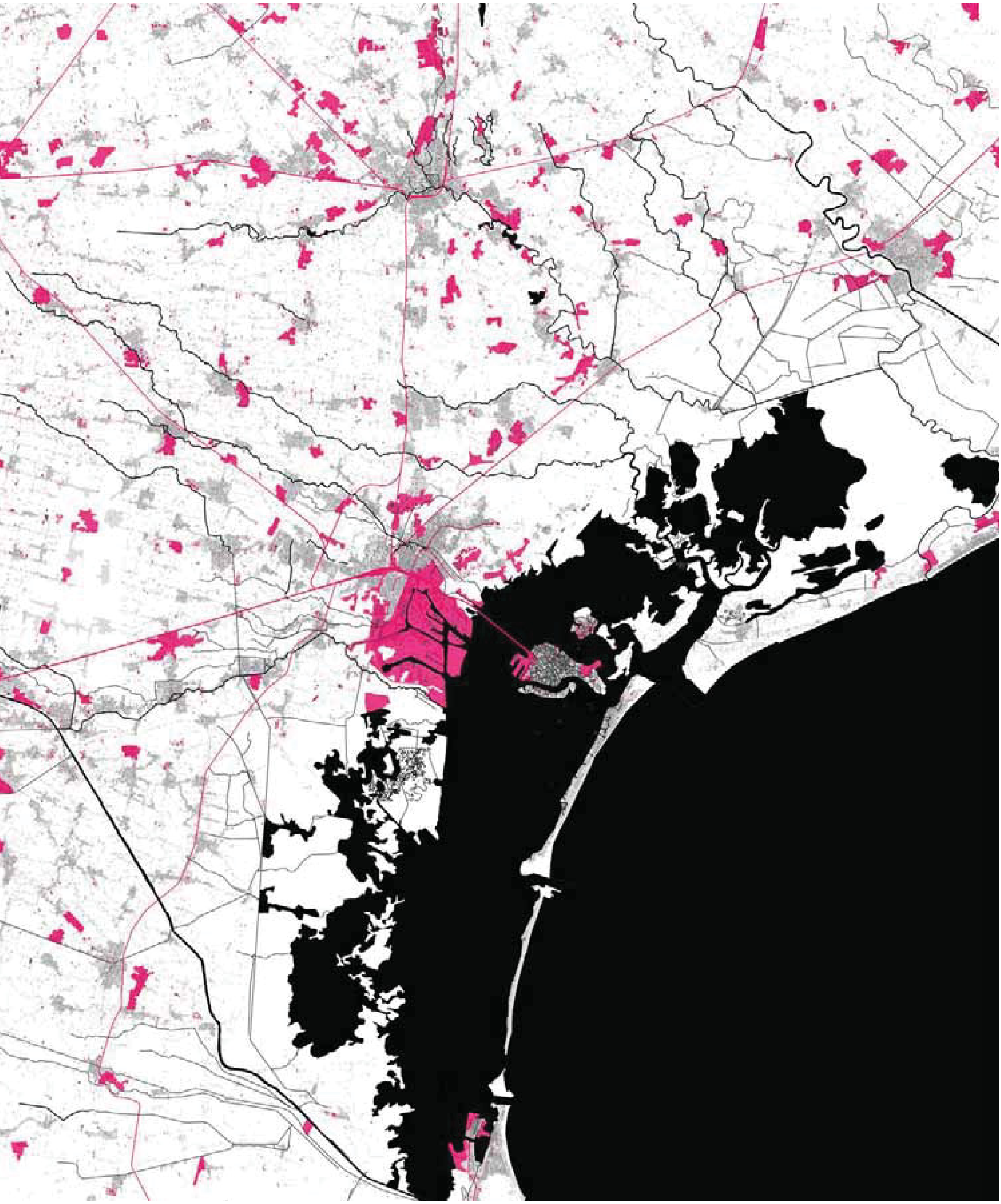


Fig. 130 Industrialization and railway network in the central Veneto region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)



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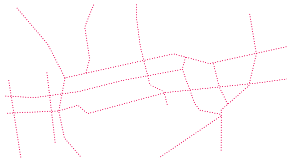
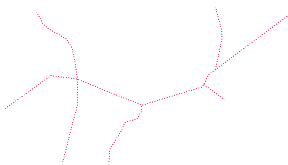
industrialization and road infrastructure



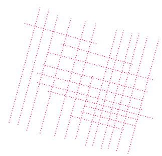
The motorway infrastructural network in the Ruhr region started to be developed since the 1920s, with the proposal of creating an East-West 3-lane motorway connecting Duisburg with Dortmund and with the implementation of the Reich Autobahn, parallel to river Emscher (Reulecke, 1984). In terms of regional accessibility, the dense Ruhr agglomeration is internally served by three parallel East-West motorway axes that are approximately 10 km apart from each other and which drain the high vehicular congestion moving along the principal axis. On the contrary, North-South motorway connections, which branch the Ruhr agglomeration to the rest of German territory, are principally situated on the edges of the network, and in very few cases they completely cross the polycentric system, so making them insufficient. In this case, the secondary road network must respond to the flows that move along North-South direction.
Two main trends are recognizable looking at the cartography concerning the relationship between industries and road infrastructure:

- after the World War II, the arrival of motorway axes kicked off the delevopment of huge industrial sites between Emscher and Lippe river;
- the primordial industrial sites along the ancient Hellweg route and the Emscher river, which were already branched to a dense railway network, have also been connected by the East-West motorway system, so beneficiating of an interesting intermodal situation which allowed them to consolidate their role as the principal heavy industrial sites of the region.



According to Tosi and Munarin (2001), the central Veneto region is clearly organized around three scales of road infrastructure which have very different relationships with the industrial fabric:

- a *sparse network,* made of national motorway axes, connects the major urban poles and their concentrated industrial areas to the national and international scale, becoming fast regional crossing axes rather than daily distribution axes for local inhabitants;
- an *intermediate network* which links the polycentric structure of medium-size urban centers and along which some mixed commercial and industrial *agglutinations* (Savino, 1998), the so called "strade mercato" (market roads), spontaneously settled;

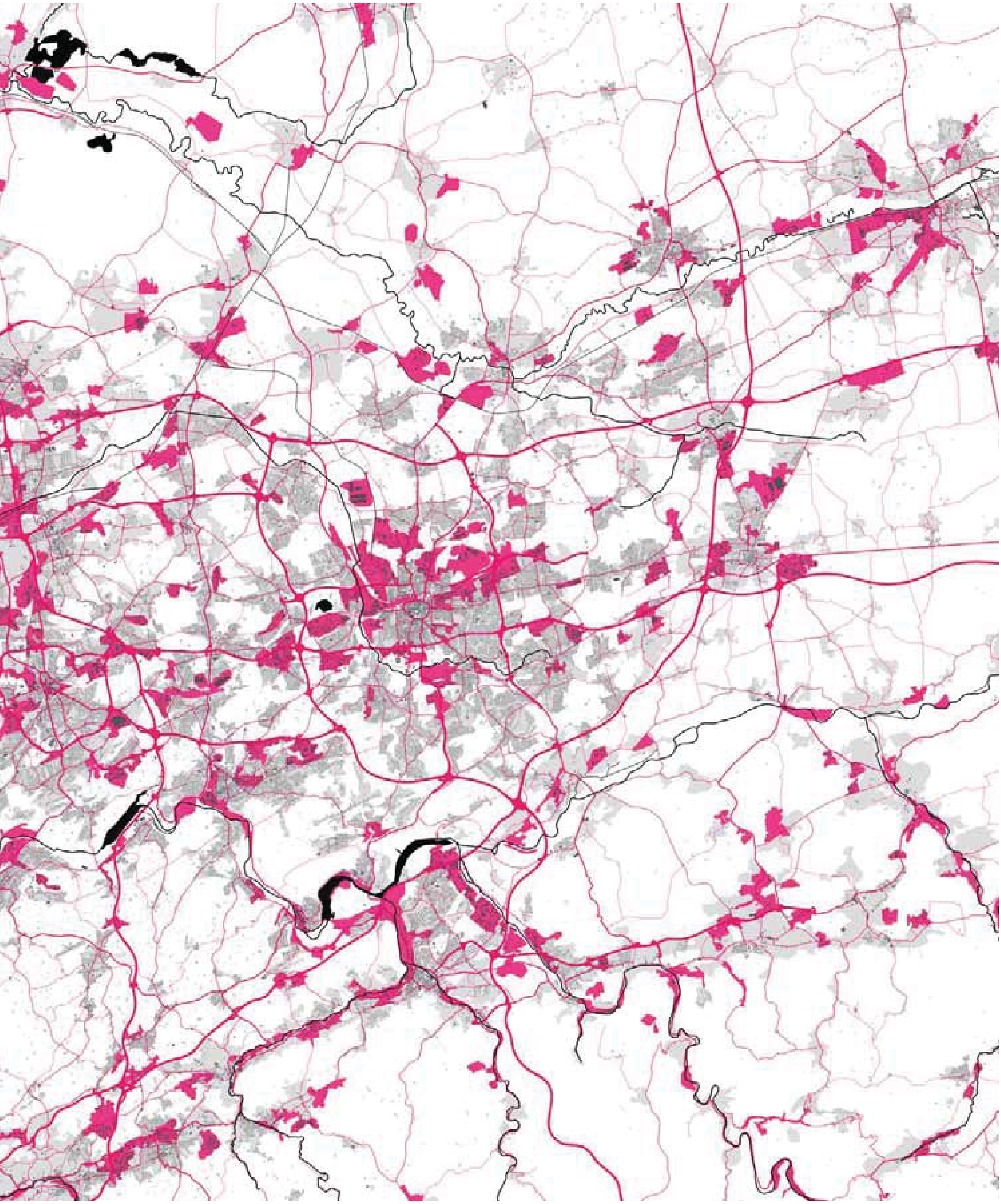


- a *capillary network* of secondary roads which nourishes in a *porous* and *isotropic* way the wide and fragmented urban fabric, interrelating it with the small urban centralities dispersed in the countryside.

This very local infrastructural scale is the one that interests us most because it underpins the functioning of the economic and industrial decentralized system of the region. In fact, the widespread capillarity of the local road network allows low dense territories to be used in an extensive way, being very well connected

to decentralized production areas.
The origin of this pervasive road network dates back to the *centuration of the territory of Patavium (Padua)* carried out during the first century BC by Romans for agricultural purposes. The land was organized into *centuries*, that means square areas of about 710 meters in length, that had to be divided into smaller farms for settlers. The Roman centuriation extended between the present provinces of Padua and Venice, an area which is still characterized by a remarkable regularity of the secondary road network. The orientation of the centuriaton is not aligned according to the absolute cardinal points, but has an inclination of about 14.5 degrees respect to East-West axis, so that roads follow the light slope of the territory, better discharging rainwaters, and fields are better exposed to the sun.
This agricultural landscape and the interaction among its peculiar items (roads, farms, ditches, irrigation channels) created the basis for the development of an extensively, but not fully, inhabited territory which results to be adequately infrastructured. As stated by Tosi and Munarin, at the beginning of the XX century Veneto region concentrated on its territory 17% of the Italian municipal road network, so confirming how the capillarity issue of the Roman agricultural centuriation has persisted over the centuries and has become a territorial identity. Calabi (1979) argued that in the 1930s the principal infrastructural transformations in Veneto region concerned the densification of the secondary road network, in terms of completion and branching of the existing network.
Subsequently, infrastructure policies in Veneto have focused on large infrastructure works, which were distributed over the territory with a total indifference to the existing palimpsest, but were supposed to better connect the region with the major national and European urban centers, leaving behind investments for the completion and maintenance of the secondary road network. With a great critical sense and with a concrete knowledge of the environmental risks that afflict the territory, Tosi and Munarin (2001) offer us an alternative planning of investments on territorial infrastructure that is based on the realization of a large and pervasive territorial project made of small incremental infrastructural works on the secondary road network and its edges (canals, ditches, cycle paths, sewers, etc.), which become structural for the management of the hydraulic and environmental risks of the region, in order to ensure a long-term territorial stability and to adapt the network to new required performances.

Fig. 131 Industrialization and road network in the Ruhr region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)



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URBAN AREAS

INDUSTRIAL AREAS

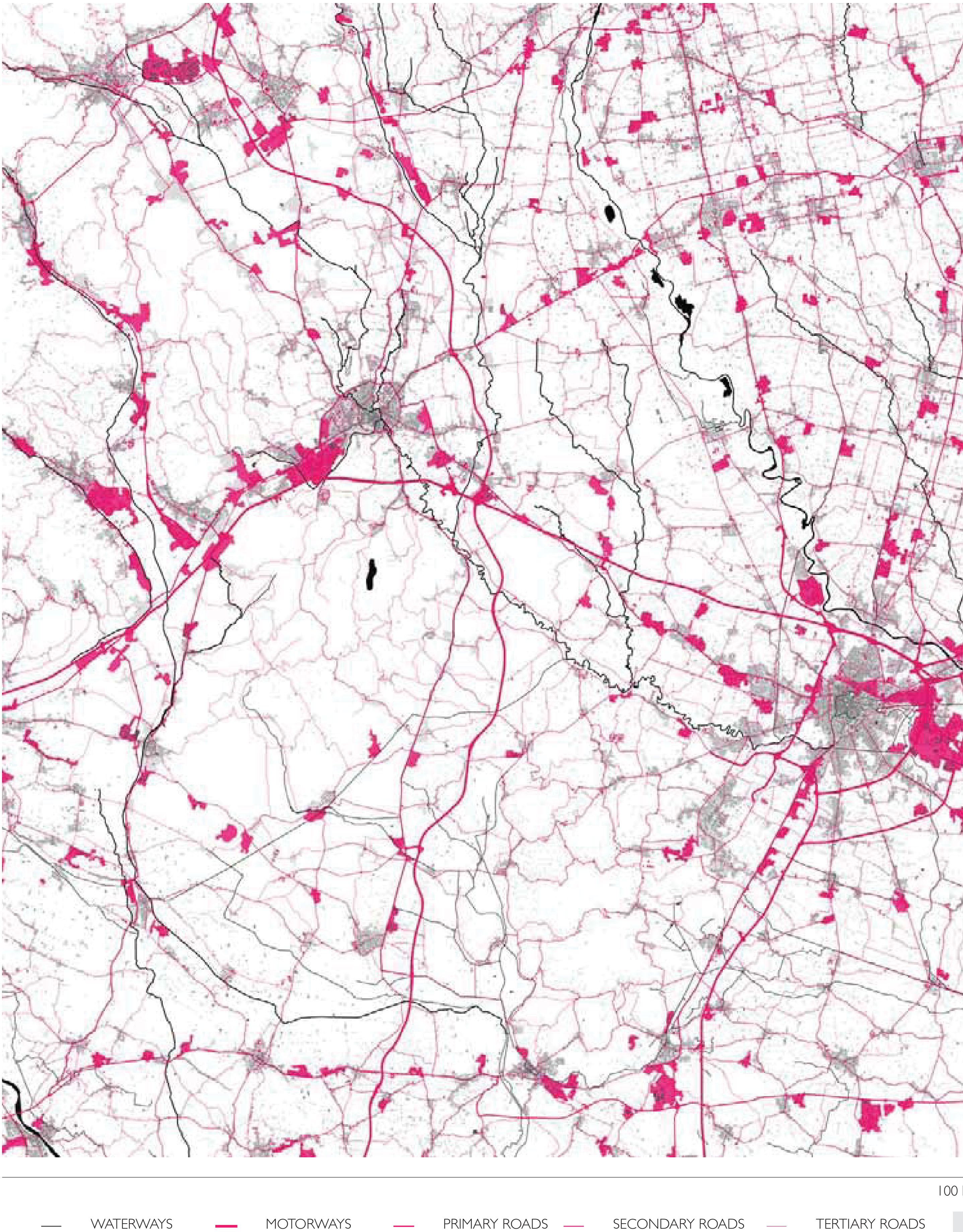


Fig. 132 Industrialization and road network in the central Veneto region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)

km

URBAN AREAS

INDUSTRIAL AREAS

polycentrism

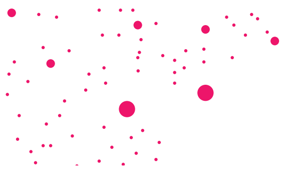
The comparative analysis of the two case studies under the lens of their polycentric territorial structure reveals how the two models work in a completely different way. The massive industrialization of the Ruhr area led to a significant wave of migration from rural areas.

Two main trends characterized urban areas' expansion according to their geographical situation:

- along the Hellweg trading route, the already existing urban centres (Essen, Bochum, Dortmund) had a remarkable radial expansion until industrial boundaries in the outskirts;
- moving North, towards the river Emscher, the lack of former consolidated semi-rural settlements encouraged a linear development of urban areas parallel (Oberhausen) or perpendicular (Gelsenkirchen) to railway infrastructures.

As already seen before, at the beginning of the XX century, the political and territorial fragmentation began to raise the issue about how to manage a regional growth which lacked of a unitary structure and development strategy. The *polycentric* model prevailed over the *metropolitan* one because of the presence of several medium cities presenting similar growth rates, high urban densities and no hierarchical dependences towards one major urban centre (Reulecke, 1984).

In the following decades up to 1980s, the continuous urban growth of the polycentric urban system made the administrative boundaries no more recognizable. Urban areas merged in a densely built-up area, which enclosed industrial, commercial and administrative clusters together with some fragments of agricultural and natural landscapes.



The polycentric territorial development of the central Veneto region is based on completely different assumptions. Territories result to be extensively built, but not completely, through low dense, but not homogeneous, urban fabric. Built areas alternate with large open spaces. The existing and dense territorial local infrastructure was the pre-condition for a dispersed inhabited territory and for an extensive use of territory, which became not only physical but also cultural. Secchi (1996) argued that dispersion represented a possible response to urban habitability crisis during the 1970s and 1980s.

According to Indovina (1990), at the end of the XIX century, when the first small and dispersed industrial activities settled in decentralized areas and carried local economic developments, the central Veneto was affected by an internal relocation process of local inhabitants, but no massive migratory phenomenon was registered. The consequent rural settlements, called by Indovina (1990) "campagna costruita" (built countryside), were based on the role of the *family-home* institution as the minimal social organizational unit, which compensated the lack of public facilities. This internal process continued for some decades until the 1970s, when a growing tendency to abandon agricultural activities in favor of the industrial sector gave the start to a massive social substitution in rural areas. In fact, the urban middle class began to desire to move towards small rural villages, in order to get closer to the decentralized workplaces and to search for better living conditions corresponding with their imaginary lifestyle. This dynamic of social renewal entailed a systematic transformation of the Veneto countryside landscape, as the bourgeoisie, no longer interested in maintaining the agricultural function of the land, transformed fields around their detached houses into private gardens, covered by vast grasslands and trees. Due to the consistency and the physical transformations of this phenomenon, Indovina (1990) identified it as a new phase of territorial and urban organization called "urbanizzazione diffusa" (diffuse urbanization), a preliminary step towards the "città diffusa" (diffuse city), which corresponds to an organizational model characterized, during the 1990s, by the decentralization of urban and public facilities in small and medium size centers. The *città diffusa* presents itself as a city-territory constituted by a diffused polycentric structure made of small and low dense urban centers, immersed in an agricultural context, where the few major cities don't play the strongly hierarchical and centralized role of a *metropolitan centre* towards its peripheral territory. The decentralization dynamics of commercial and public services in the dispersed territories generated a *polarization* phenomenon of planned single-use enclaves (residential areas, shopping malls, sport and school equipments, etc.) which reconfigured Veneto territory through homogeneous functional areas that interrupt the functional mix made of spontaneous incremental additions.

two territorial images

According to Tosi and Munarin (2001), it is possible to recognize three types of territorial image according to the hierarchies between territory and city:

- *territory is separate from the city* and, in this dichotomous relationship, it opposes the dispersal of the city by attempting to fix limits to expansion, such as through the use of green belts;
- *territory is integrated into the city*, because the natural space insinuates in the dense and compact city, drawing its structure and future development;
- *territory is a new form of city* and it represents a new way of living an extensive livebale space made up of different parts.

Our two territorial case studies can be considered the physical expressions of these territorial hierarchies, in particular the Ruhr region stands for a *territory integrated into the city*, and central Veneto region for a *territory as a new form of city*. On these territorial images we want to refer the territorial restructuring theoretical thinking which recent urban literature dealt with.

Fig. 133 Polycentrism in the Ruhr region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)

km

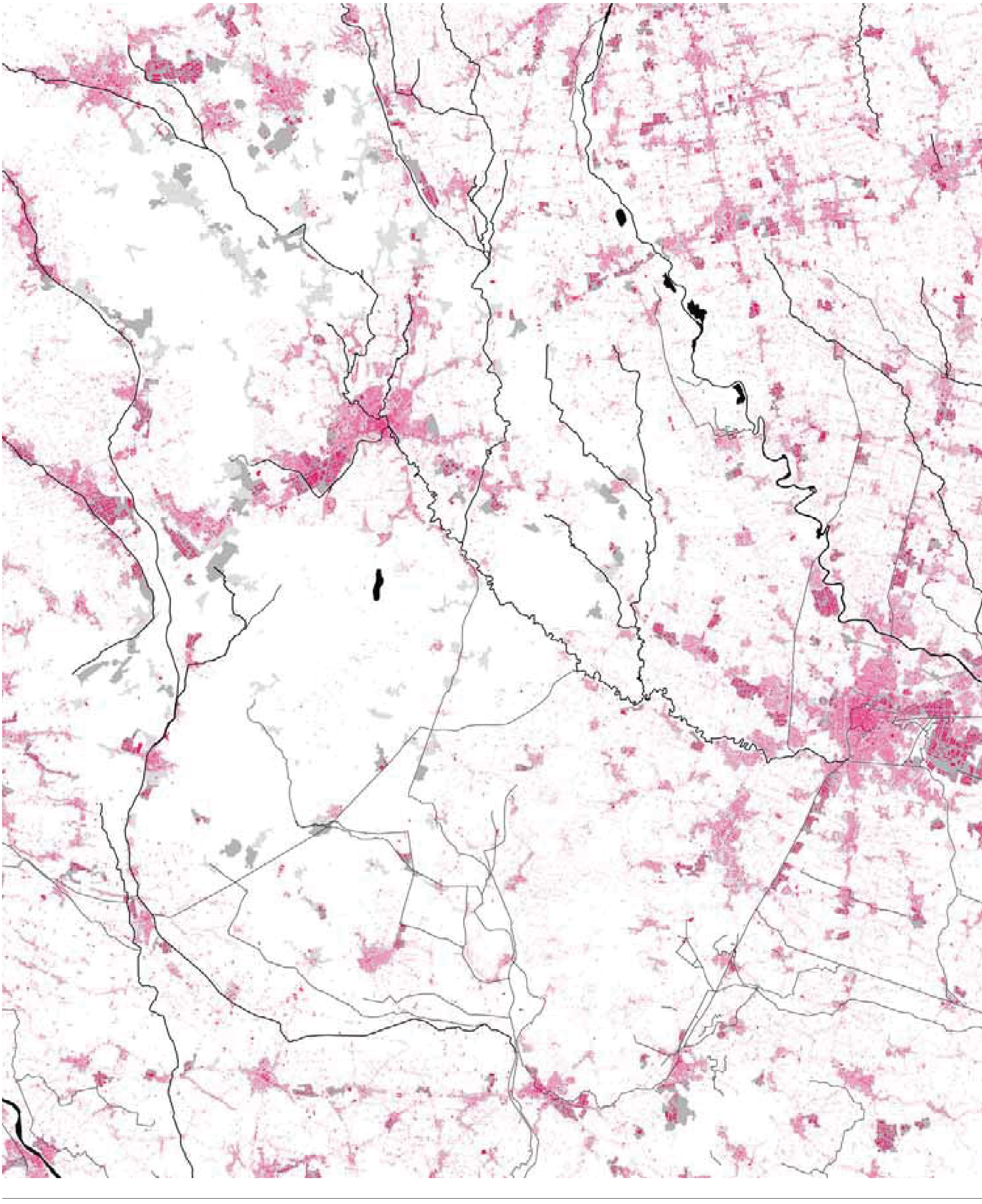


Fig. 134 Polycentrism in the central Veneto region in 2012 (source: Corine Land Cover, Diva-GIS metada; elaborated by the author)

km

metropolitan archipelago

Even if our previous analysis confirms the polycentric structure of both territories and denies the existence of those vertical and centralized hierarchies established between a *metropolis* and its *metropolitan area*, the recent urban literature supposes a territorial reorganization of the Ruhr agglomeration towards the *Green metropolis* vision (Sijmons, 2014) and of the central Veneto region towards the *Horizontal metropolis* one (Viganò, 2015).

Why do recent studies come back to a debate that seemed to be disambiguated?

According to Indovina (2003), "metropolization of territories" is the current tendency which is leading any previous territorial structure (*polycentrism, città diffusa* and *metropolis*) to the new model of the "metropolitan archipelago" (Indovina, 2005). At this point of the research and in order to focus on the changes brought by this new territorial form, it becomes important to remind the characteristics and the differences underlying each type of the territorial structure above-mentioned:

- the *metropolis* stands for a compact urban area, with a high density rate, a large number of inhabitants, which is generally characterized by a high level of concentration in terms of activities and public equipments;
- the *metropolitan area* underlies a mono-directional bond with a metropolis, in which it is identified and on which depends through "hard hierarchies" (Indovina, 2005) in terms of flows of inhabitants from the periphery towards the center, both for mandatory flows (home-work, home-school) and of non-mandatory ones (leisure and free time);
- *polycentrism* (and *città diffusa* as a particular low-dense polycentric expression) lies on a territorial structure organized around several centers which maintain their autonomous internal functioning, because they are equipped with all the necessary services and activities, and they establish "soft hierarchies" among themselves, thus contributing to an extensive use of the territory being provided with a dense infrastructure network.

Talking about "metropolitan archipelago", we mean an extensively urbanized territory, but which establishes *soft hierarchies* among its parts and looks more like a polycentric territorial model, with some structural differences:

- the first one can be found in the use of the term *archipelago*: according to Indovina (2005), we are witnessing a tendency of "specialization of the territory" that results to be organized around monofunctional micro-poles of excellence (for commercial activities, leisure, health, higher education, research, etc.). These single-use platforms have a wide fruition and are homogeneously distributed in several polarities on a wider area. Thus, territory results to be a mosaic made up of single-function tiles, namely, an *archipelago* of homogeneous and clearly distinct urban functions put them together next to each other. The real difference with the polycentric model is due to the *integration process* of the metropolization of territories: in fact, territories are more and more the support of dense physical and intangible networks among the specialized poles and their users;

• what has just been discussed is the prelude to the second change of this territorial organization: the *metropolitan quality of the territory* consists in gaining conscience of the richness which can be experienced in the diversity. In particular, even if both mandatory and optional flux registered a significant growth rate, the optional ones (for leisure, free-time, culture, etc.) are those which showed a real growth peak, allowing every inhabitant to build his city experience based on the mosaic tiles that are part of his interests and needs, so enlarging the extensive use of territories towards *individual geographies*.

It must not be forgotten that the *metropolization of territories* results to be the effect of the diffusion of technological innovations in production and communication sectors, as they became territorial organization factors that opened to unexplored aggregative possibilities.

Thanks to the previous clarifications about the metropolization of territories, it seems evident that the use of the term *metropolis* is no longer in its original definition, but in a kind of contraction of *metropolitan archipelago* concept. In this sense, *Green metropolis* and *Horizontal metropolis* open to new interpretations and reveal a new potential in territorial planning that previous territorial organizations couldn't imagine.

green metropolis

We think that the restructuring of the Ruhr region towards the *Green metropolis* vision results from the already presented planning experiences during the XX century: Schmidt's General Housing Estate Plan and his proposal to establish a regional park in order to limit productive areas' expansion (1912) and IBA Emscher Park experience during the 1990s. The common thread based on the renaturalization of an industrial landscape was to propose, at the beginning of the XX century, a more qualitative living environment and, at the end of the same century, to revitalize a depressed economy through services, tourism and culture, although the territorial images seem to be different. Schmidt's proposal responds to *territory is separate from the city* category because nature is used as a containment tool against industrial expansions. On the contrary, IBA Emscher Park matches with the *territory is integrated into the city* category, because the consolidation of a park through the reconnection of natural and agricultural fragments becomes the infrastructural backbone for the territorial mosaic and allows to foster a dialogue across different scales of intervention.

Thus, when Sijmons (2014) evokes a transnational "Green metropolis" which, in addition to the German territories, includes even those Belgian and Dutch territories which have been historically shaped by coal extraction, we suddenly perceive that a metropolitan archipelago can overcome administrative borders. In this sense the notion of "Green metropolis" seems to better respond to the third territorial image described by Tosi and Munarin (2001), that is to say *territory is a new form of city* category, and identifies in a twentieth-century energy landscape the main analogy among territories. Thus, the potential of the territorial restructuring consists of a polycentric structure which is characterized by large open space areas and which is the result of the development of communities near to mining sites, together with an extensive infrastructural network. As those areas were historically rooted on twentieth-century fossil fuel energy landscapes, according to Sijmons the potential for the entire region is related to the ability to renew its image and its economic model by entirely autoproducing its energy needs by local renewable resources (Sijmons, 2014). Just to give an example, the dismantled mining industry left several kilometers of underground tunnels which could be converted in an infrastructural support for an alternative heat network by using the residual heat from old mine shafts' water and supplying part of the region's needs. Moreover, the integration and diversification of other forms of renewable resources (i.e. biomass from existing wooded plateaus and from poor and less suitable soils for food production, hydraulic energy from the transformation of former lignite mine in artifical water reservoirs, geothermal heat potential) could enhance a territorial clean energy transition which looks at *green economy* as the economic model for the forthcoming Green metropolis.

Fig. 135 Lignite mines as new power plants in the Green Metropolis (source: Dirk Sijmons)

horizontal metropolis

Talking about some different territorial situations, such as Bruxelles region (Secchi and Viganò, 2012) or the Swiss territory (Viganò, 2015), Bernardo Secchi and Paola Viganò recognized the immense potential which underlies a fragmentary and dispersed urban condition. According to them, it consists of a spatial and natural capital capable of constituting the pre-conditions for the construction of a sustainable and innovative urban dimension, the so called "Horizontal metropolis", that is to say "a metropolis that establishes both non-hierchical relationships between its different parts as well as osmotic relationships between built and open space, between mobility infrastructure and dwelling places" (Secchi and Viganò, 2012).

The same metropolization effects are recognizable in the low dense and decentralized polycentric territories of the central Veneto region, which result to be the stratification of agricultural and non-agricultural activities, of a rich infrastructural network and of a specific socio-economic culture. In this sense, considering the central Veneto region as a "Horizontal metropolis" permits to focus on its potential as part of a wider energetic, ecologic and social project.

If the very feature of the central Veneto region consists of its dispersed industrial pattern and the widespread and isotropic infrastructural network, the "Horizontal metropolis project" aims at the improvement of living conditions in those productive areas, looking for a new mixity which can integrate public spaces suitable for daily life, taking advantage of a pervasive proximity to green and agricultural spaces capable of enhancing the environmetal quality of life.

The "Horizontal metropolis" considers the territorial palimpsest as a renewable resource capable of regenerating itself and of encouraging innovative synergies among its components.

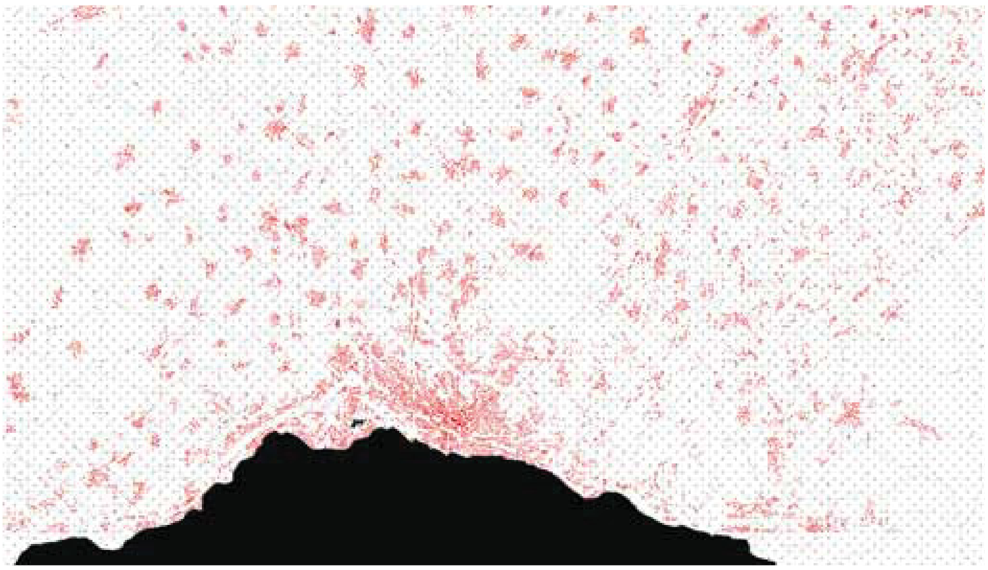


Fig. 136 Flyer for the exhibition The Horizontal Metropolis at the Venice Biennale 2016 - Lausanne case study (source: Lab-U, EPFL Lausanne)

An urban model for the third industrial revolution

weak urbanization model

Between provocation and utopia, since the mid-1990s Branzi prefigures to seek for an ideal urban model which loses its tight bond with the historical debate about the correspondence between urban form and function, but instead lies on the evolving relational flows among society, economy and land uses. This new model should better respond to contemporary urban conditions, which are increasingly permeated and affected by the spread of information and communication networks which shift societal needs towards an immaterial and invisible reality. Branzi's thinking is principally influenced by two main theoretical contributions: Gianni Vattimo's *weak thinking*[1] and Zygmunt Bauman's *liquid modernity*[2]. The minimum common denominator on which Branzi builds its personal "weak urbanization model" (Branzi, 2006) turns around the concept of *uncertainty* which characterizes contemporary relational dynamics, and substitutes the rigid certainties on which classic modernity rooted its philosophical thinking, and, in urban terms, which can be easily exemplified by all those strong and definitive urban transformations typical of modernist period and by those dicotomies which survived until the XX century, such as *city vs countryside*, *industry vs nature*.

Weak urbanization is a theoretical attempt to discard the rigid and centralized urban models, deriving from the rational logic of industrial progress, with new flexible and diffused ones which better answer to post-fordist economy's challenges taking advantage of its weak and distributed productive logic. Territories which can express this potential are those that classical planning has never been able to categorize within its rigid definitions, being half urban and half agricultural, those hybrid territories that we usually call *periurban*. Branzi sees a great potential in these territories because it is where the layering of intense urban relational spaces and agricultural production could create a new urban form which overcomes the old conflict between city and countryside through an innovative mediation. This reflexion resulted in *Agronica*, Branzi's first weak

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1 According to Gianni Vattimo, the *weak thinking* corresponds to a particular type of knowledge characterized by the profound rethinking of all the notions served as a foundation for Western civilization, putting the idea of absolute truth into crisis. According to this perspective, only historical conditions, which no longer exist, allow traditional values to be perceived as such and for this reason their claim of absolute truth must be put into crisis. There are some reasons that bring Vattimo to adhere to the *weak thinking* theory: knowledge has become so complex that it is not conceivable the existence of a science that regains all the others in a unified way; mass media are constantly in contact with other cultures and it is increasingly difficult to reduce everything to a single matrix; evidence must not be considered as a sign of truth because it is produced by habits, social pressures, conventions. See Vattimo, G., Rovatti, P. A. (eds.) (2009), *Il pensiero debole*. Milano: Feltrinelli.

2 *Liquid modernity* is a concept formulated by Zygmunt Baumann which has profoundly marked the common language since the beginning of the XXI century. According to him, with the end of the great narrations of the twentieth century, we are going through a phase that dismantle those certainties, from welfare to politics, by mixing them with nihilistic impulses. The result is a confusing present which no longer has headlights to follow and which is characterized, for example, by the crisis of the state in face of globalization, by the distance of the individual and hedonistic satisfaction from a community mission. See Baumann, Z. (2003). *Modernità liquida*. Roma-Bari: Laterza.

urbanization experiment developed in 1995 for the Domus Academy Research Center and Philips Design Center. It consists of a highly technologized and diffused agricultural park which integrates "agricultural and natural landscapes with evolved, but no longer totalizing, urban services" (Branzi, 2006). Moreover, the deployment of electronic instrumentation permits to carry functions and work everywhere, so making possible the definitive separation between form and function in the architectural practice and the integration of a decentralized, seasonal and eco-friendly energy production among architectural features.

In fact, "we have gone from the age of functionalism to the age of functionoids, instruments that do not possess a single function, but as many functions as the operator's needs" (Branzi, 2006). In this sense, the architecture of weak urbanization models has to lose the figurative code of its "cathedrals of the modernity" and acts more like a "personal computer", being adaptive to evolving societal needs, and like "agriculture", integrating time as a design element. *Weak, reversible, imperfect, evolving, provisory, enzymatic, elastic, traversable* are adjectives used by Branzi to describe how a non-figurative architecture should act as agricultural systems, in order to be adaptive to those horizontal hierarchies which underlie the metropolization of territories.

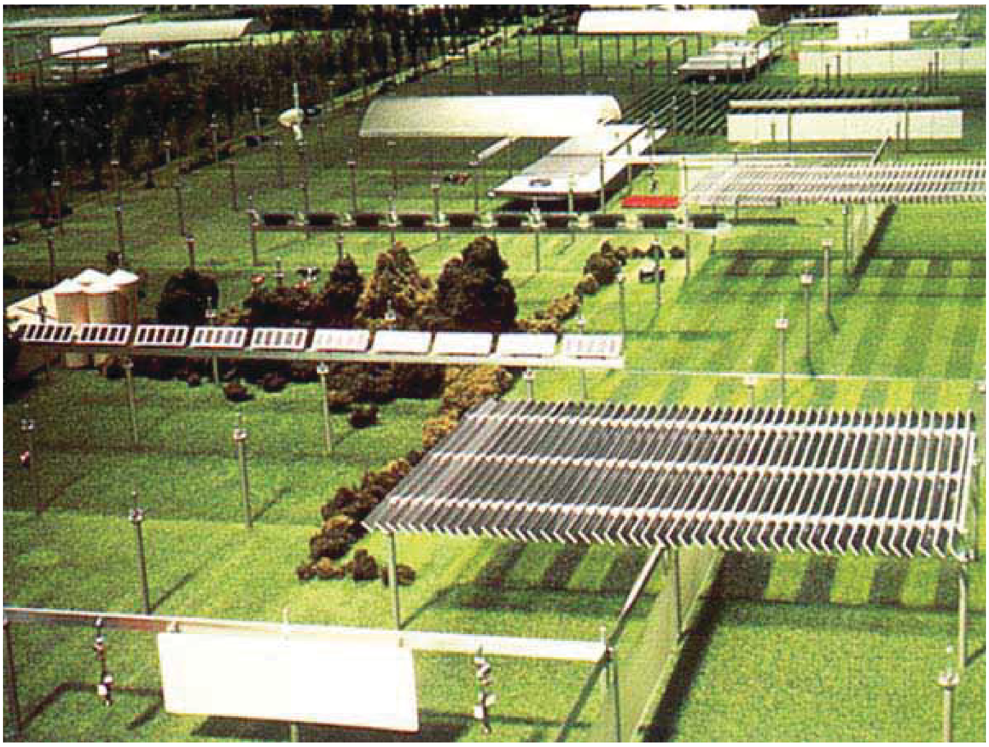


Fig. 137 Agronica (source: Andrea Branzi)

Fig. 138 Agronica (source: Andrea Branzi)

Fig. 139 Agronica (source: Andrea Branzi)

The "Favela" (Branzi, 2006 and 2010) has to be the reference for the aggregative model of a non-figurative architecture, because it describes a spontaneous process, capable to foster reversible facilities and to be responsive and evolutive towards time and the changeable needs of relations. It is interesting to notice that, some decades before him, even Yona Friedman (1978) speculated on the "survival architecture of bidonvillages" as a possible response to industrialization simulacra, focusing on their self-sufficient and synergic organizational model to provide water, food and weather protection to their inhabitants.

from energetic infrastructure to energetic landscapes

In the light of these considerations, if the figurative architecture of the *cathedrals of energy industry,* which contributed to raise the barriers between industry and nature, is currently losing its centralizing role, the non-figurative architecture of a diffused energy production system should blur those rigid limits and reintegrate productive activities within a greater harmony with natural dynamics.

Looking towards the energetic transition of the third industrial revolution, we think that the *fossil fuel infrastructural reconversion* should enter the domain of landscape architecture and contribute in fostering the *territory as a new urban form* vision, consisting of a widespread existing infrastructural heritage which could constitute the support for a distributed renewable energetic production and storage.

If former metropolis were fed by few and centralized power plants, the boundless weak urbanization model is supplied by those *energetic landscapes* which could produce renewable energies valorizing the hidden energetic potential coming from the metropolization of territories' process .

The physical interrelationship of *fossil fuel meshes* becomes a suitable territorial feature to propose their conversion as *energy backbones* for a diffused energetic production and storage.

A statistical Adrion's energy dependency on fossil fuels

international energy agency database

Historical and comparative cartographic analysis allowed us to explore how territories have been morphologically influenced by oil hierarchies, in particular those related to geographic location, proximity to natural heritage and the consequent urbanization dynamics. Now, in order to understand the magnitude of how complex, but at the same time how necessary, could result to envisage a radical revolution of our current energy production, we would like to analyze some statistical data obtained from the *International Energy Agency* database (www.iea.org).

The following charts quantitatively describe the energy status, in terms of production and consumption, of countries belonging to Adrion region, in particular:

- the balance between imported and domestically produced energy sources and their use in the principal sectors;
- the final energy consumption, subdivided by energy type, and its breakdown among consumption sectors.

Data want to compare the current situation, taking the year 2014 as the most recent available reference, and the energy situation in 1990, that is to say the reference year for the *national greenhouse gases emissions* (GHG) in Kyoto Protocol and with respect to which the signatory countries have taken the committment to reduce their GHG emissions by at least 8.65% over the period 2008-2012.

Italy's fossil fuels dependence 1990-2014

Between 1990 and 2011 Italian population increased by 4.5%, passing from 56.7 million to 59.3 million (source: Istat). Although this is not an exhaustive figure that fully justifies the rising energy demand and consumption (we must not forget the incidence of production activities and services), the final energy consumption in Italy has increased from 114.8 Mtoe (Million of tonnes of oil equivalent) to 116.5 Mtoe in the same period, thus defining an increment of +1.5%. Imported crude oil represents the pricipal energy source in Italy, both in 1990 and 2014, although there has been a significant reduction in its use during this period. More specifically, it fell from 88.8 Mtoe (total oil imported and extracted in Italy) in 1990 to 67 Mtoe in 2014, thus showing a significant reduction of 24%. It is interesting to note that in Italy an inverse trend related to the quantity of local crude oil extraction can be observed, in fact it is necessary to report an increase of 15%, passing from 6.8 Mtoe to 7.9 Mtoe in 2014. These data seem to indicate that Italy wanted to comply with its commitments as a signatory of the Kyoto Protocol, reducing overall carbon dioxide emissions generated by oil for energy purposes, but at the same time wanted to increase its internal energy independence.

Another important element that describes the Italian energy policy of recent decades is the radical increase in gas consumption, which partially replaces oil. In fact, the growth registered between 1990 and 2004 in the use of natural gas (whether locally produced or imported) reaches 30%, (50.6 Mtoe), thus approaching the quantity of treated oil and becoming the second most important energy source on the Italian scene. On the contrary, coal is falling, but this has never represented a central energy source in Italian energy policies due to its scarcity in the Italian subsoil.
The second graph shows the breakdown of oil consumption by sector. It is possible to see how oil, during the 25 years considered, recorded a significant decrease in the residential sector, being replaced by natural gas as the main source used for heating. The industrial sector, for both energy and non-energy purposes, marks a reduction in oil consumption, while the transport sector registers a considerable increase of 5% (32.3 Mtoe) confirming that, at present, oil fate is closely linked to the automotive and transport industry.

Slovenia's fossil fuels dependence 1990-2014

Slovenia recorded a population growth of 3.5%, from 1.99 million in 1990 to 2.06 million inhabitants in 2014 (source: Statistics Office of the Republic of Slovenia). This modest demographic growth, together with a significant economic rise, which is certainly higher than that of the Balkan area most affected by the war at the beginning of the 1990s, is accompanied by an increase in final energy consumption of about 28%, up to 4733 Ktoe. According to International Energy Agency data, the minimum amount of crude oil imported or locally produced in 1990 (600 Ktoe) dropped to zero in 2014, making Slovenia a country completely dependent on foreign oil by-products. This figure is confirmed by the fact that the only refinery in Lendava is actually being closed down. Thus, Slovenia increased the import of oil derivatives between 1990 and 2014 by 160% (from 1446 Ktoe to 3751 Ktoe). If coal was the most widely used energy resource, even more than oil, in 1990 (1591 Ktoe), in 2014 the use of coal for energy purposes fell by 35% (1060 Ktoe). In the Slovenian energy scene, it is important to remember that nuclear energy covers an important part of the country's energy needs, confirming it as the main national energy source thanks to a growth of 40% in 2014 (1660 Ktoe) compared to 1990. Natural gas has an almost irrelevant market. As far as the breakdown of energy consumption by sector and by type of energy source is concerned, Slovenia recorded a reduction in the use of oil for residential and industrial purposes, but an increase of 100% was registered in the transport sector (1726 Ktoe) over the period considered.

Croatia's fossil fuels dependence 1990-2014

Croatia represents a very particular case in point, presenting some energy trends that are completely at odds with the other countries of the Adrion region. First of all, between 1990 and 2014 the population in Croatia experienced a significant 10% decrease (from 4.78 million to 4.28 million inhabitants, source: Croatian Bureau of Statistics). Following the same trend of the demographic contraction, the total final energy consumption decreased by 5% over this period, falling to 6672 Ktoe. In terms of imported crude oil or produced in the country, Croatia recorded the highest contraction of all the countries bordering the Mediterranean sea: -58.5%, thus passing from 7367 Ktoe in 1990 to 3046 Ktoe in 2014. On the contrary, natural gas marks a 10% growth rate over the same time span (2353 Ktoe in 2014). While there has been a general high reduction in oil consumption, the transport sector is witnessing a significant rise of +65% (from 1074 to 1754 Ktoe). On the contrary, the residential and industrial sectors are reducing oil use in favour of natural gas.

Albania's fossil fuels dependence 1990-2014

In the two decades from 1990 to 2011, Albania showed a significant demographic contraction of 11%, falling from 3.2 million inhabitants to 2.83 million. The reduction in final energy consumption of 2.5% (from 2179 to 2131 Ktoe) presents a particular oil situation: if in 1990 the 1184 Ktoe of locally extracted crude oil was totally used for internal energy and industrial purposes (Albania was controlledby a very protectionist communist regime at the time), in 2014 the extraction of crude oil, together with a very small imported part, recorded an increase of 20% (1418 Ktoe), but about two thirds of this are exported to be refined abroad. The arrival of economic liberalism has made more convenient to refine Albanian crude oil elsewhere than to locally develop this industrial sector. In order to conclude the excursus about fossil fuels energetic scene in Albania, coal consumption decreased over the period considered, while natural gas has always represented a very small market niche.

With regard to the distribution of energy consumption by sector, oil has always been underused in the residential heating sector. The transport sector confirms the general trend and marks an impressive growth in oil consumption, recording a +200% in 2014 if compared to 1990, reaching 767 Ktoe.

Greece's fossil fuels dependence 1990-2014

Greece is another very particular case study which, although showing trends similar to those of Western Europe, such as for population increase (+7%, from 10.3 to 11 million inhabitants in 2015) and for a final energy consumption increase (+7%, from 14.5 to 15.5 Mtoe in 2014), it also shows a significant increase of 53% in the use of crude oil, especially the imported one due to the scarce availability of local crude oil in the subsoil (from 17.8 to 27.2 Mtoe).

The impact of coal on the Greek energy industry has always been very significant

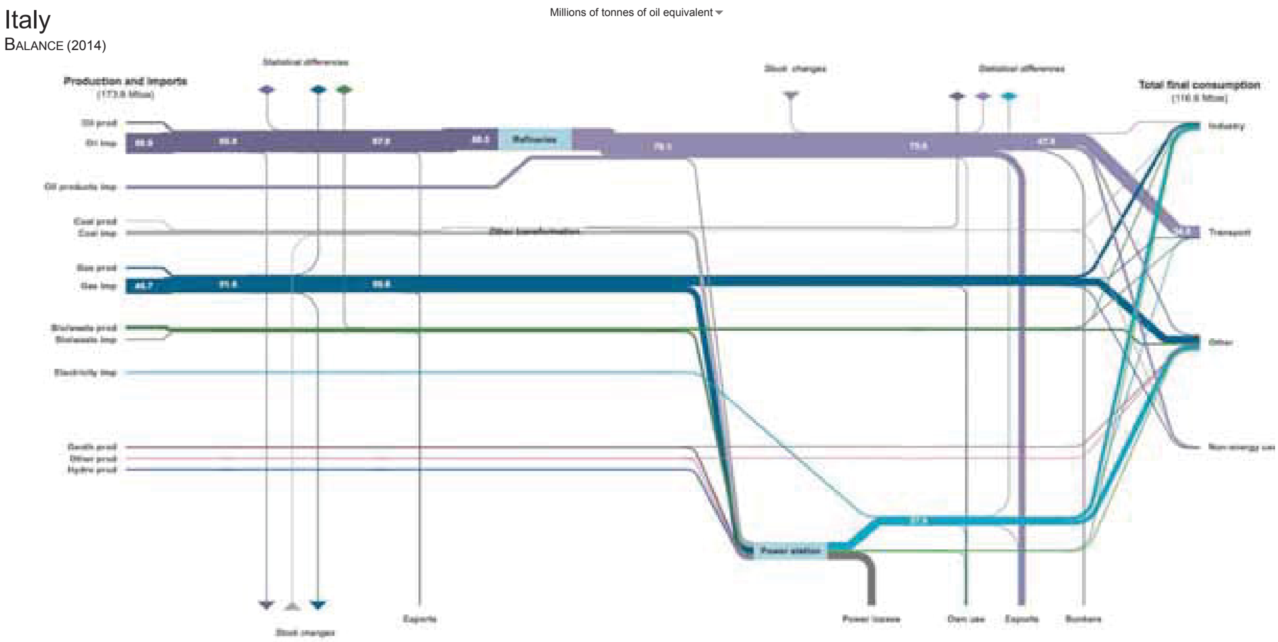
due to the large quantities of lignite available in the western Macedonia region (8.12 Mtoe in 1990). However, in 2014 lignite use for energy purposes decreased by 20% (6.52 Mtoe).
Greece's transport sector is also showing a strong growth in oil-related energy consumption (+22%, from 3.91 to 4.78 Mtoe).

general remarks

The deep dependence on fossil fuels of Adrion region's economies is evident, although the energy policies of the countries on the east and west coast differ. We can observe some trends that seem to be repeated with constancy and that we can try to synthesize as follows:

- the three EU Members States (Italy, Slovenia and Greece, we do not consider Croatia as it is part of the European Union only since 2013) register a demographic increase, which is accompanied by an increment in final energy consumption. However, among these three countries, only Italy shows a significant reduction in oil consumption for energy purposes, highlighting a remarkable shift towards natural gas use for all sectors except for transport one;
- the two Balkan countries which do not belong to the European Union register significant demographic decreases (probably linked to migratory waves) and a consequent reduction in final energy consumption. In both cases, the growth in oil by-products import values underlines a similar trend in increasing energy dependence on foreign sources;
- in all case studies we observe a reduction of oil use in the residential sector (except in Albania, where there has never been an important use of oil for heating), but the substitute energy source is different from one country to another: in Italy it is natural gas, in Greece electricity, while in Croatia and Slovenia biofuels and waste;
- in all five countries, the transport sector shows a significant increase in oil consumption between 1990 and 2014 and represents the sector employing between 50% and 75% of total national oil consumption. .

The trends described above confirm what Rifkin assumed for its "third industrial revolution" (2011), that is to say that it is not possible to consider abandoning the use of oil for energy purposes if the automotive industry does not invest in renewable energy sources such as electricity, hydrogen or algae bio-fuels.
While the challenge is certainly complicated for private transport will still require a great deal of effort, an important first step could be the massive shift to renewable energies of urban, regional and national public transport, the strengthening of which could also contribute to reducing the use of individual motorized transport.



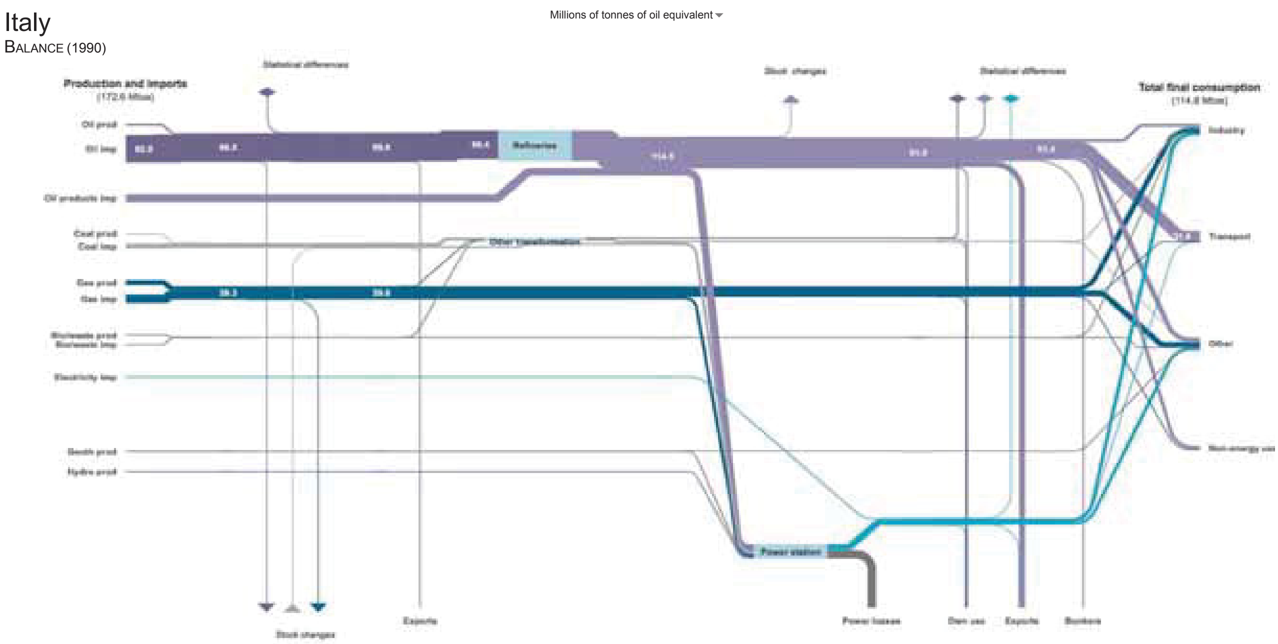
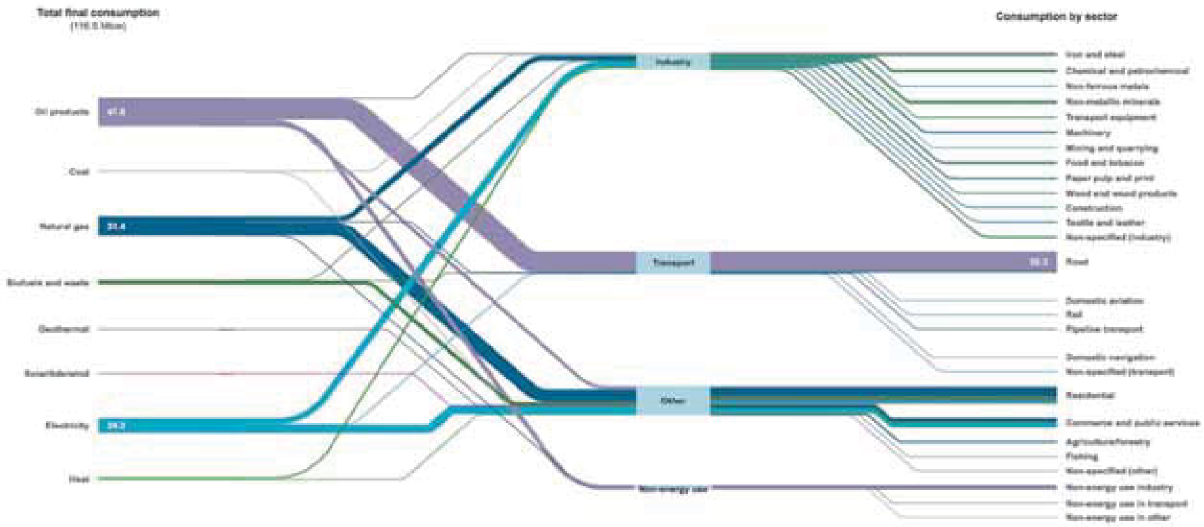


Fig. 140-141 Comparison of the energy balance in Italy in 1990 and 2014 (source: International energy Agency)

Italy
Final consumption (2014)

Millions of tonnes of oil equivalent



Italy
Final consumption (1990)

Millions of tonnes of oil equivalent

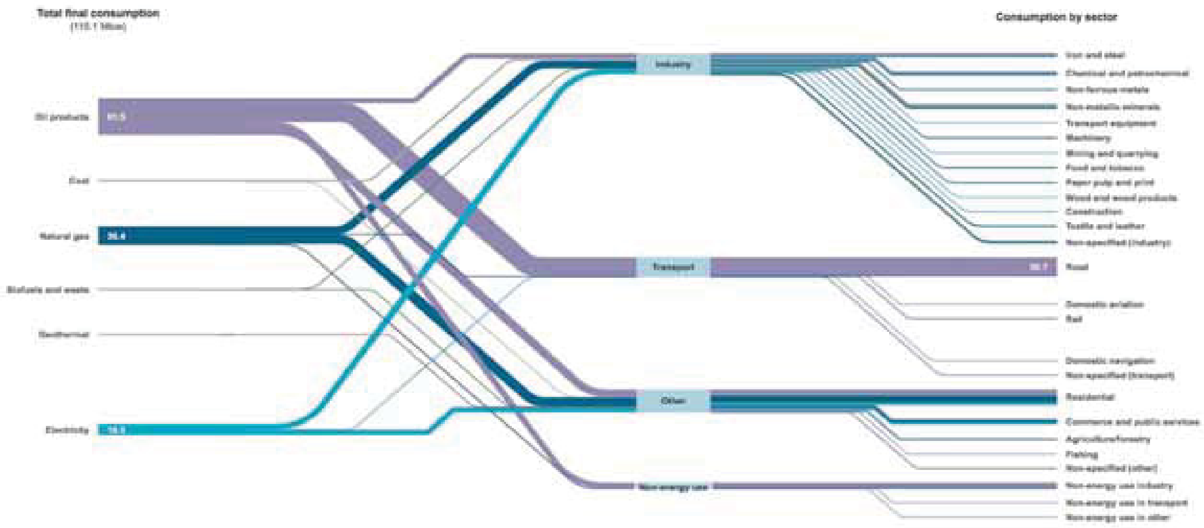
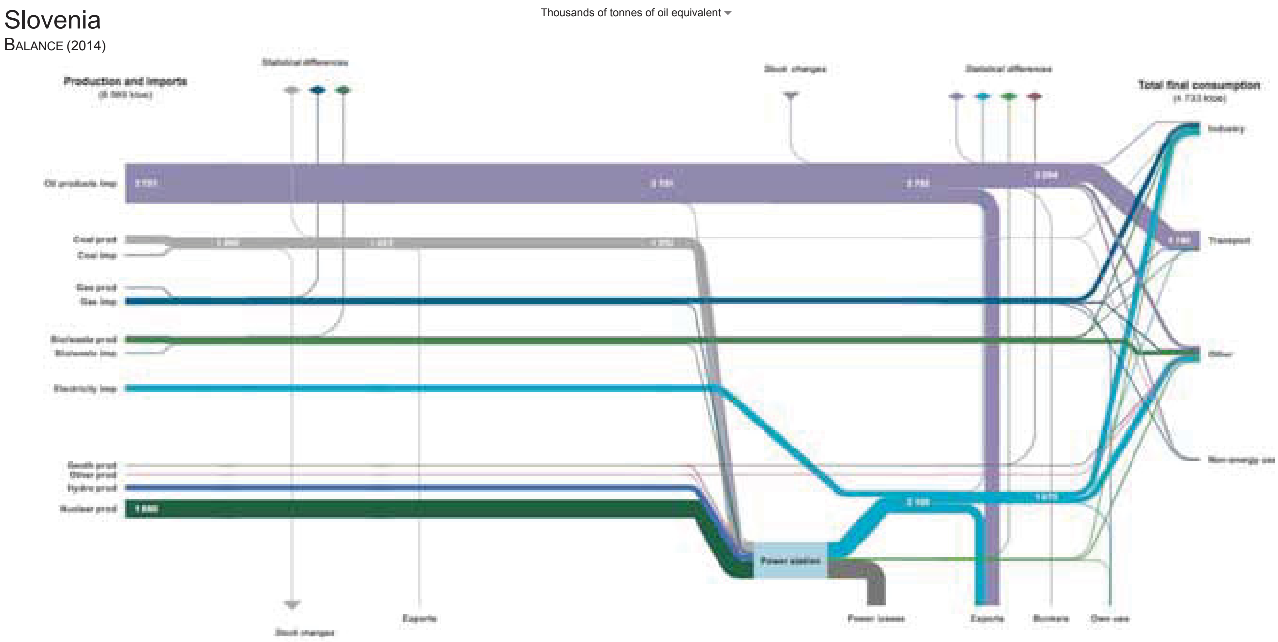


Fig. 142-143 Comparison of the final energy consumption in Italy in 1990 and 2014 (source: International energy Agency)



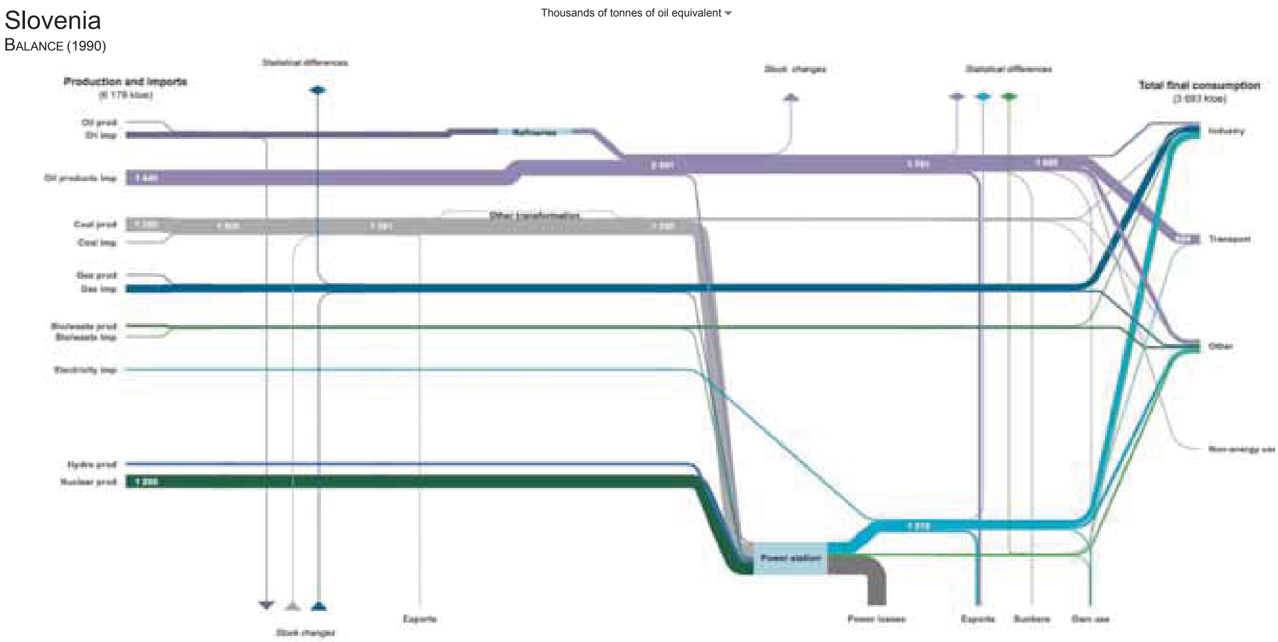
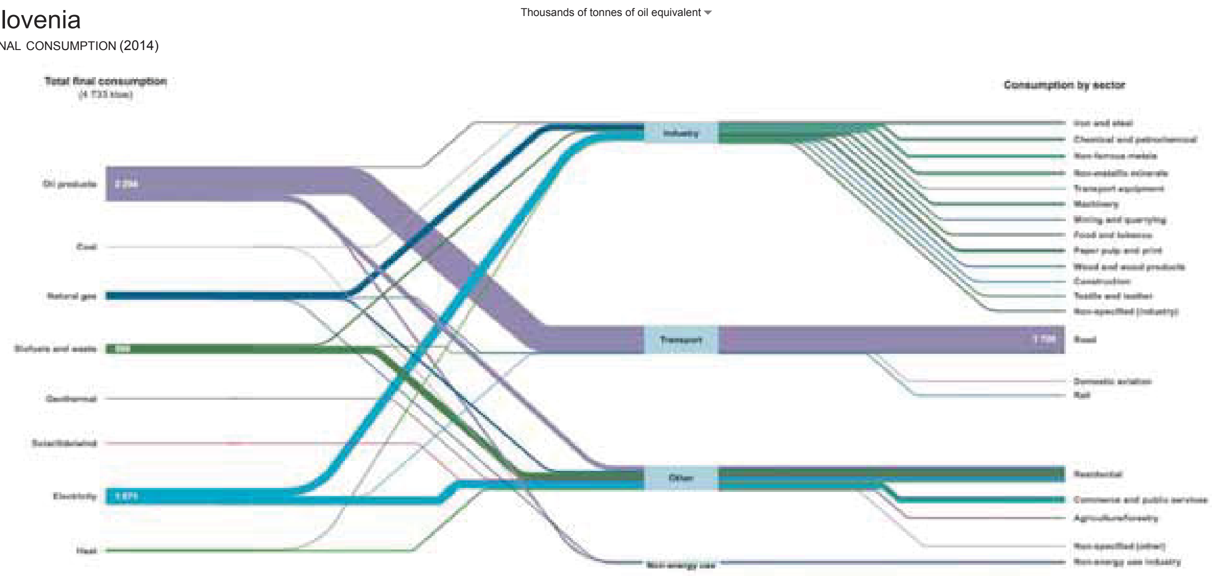


Fig. 144-145 Comparison of the energy balance in Slovenia in 1990 and 2014 (source: International energy Agency)

Slovenia

Final consumption (2014)



Slovenia

Final consumption (1990)

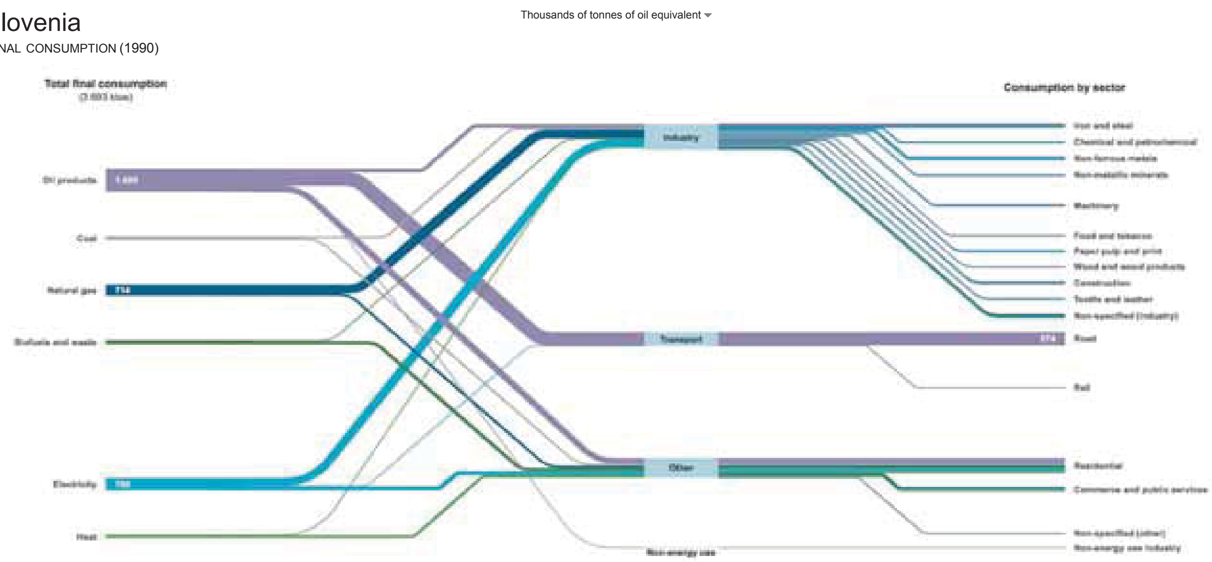
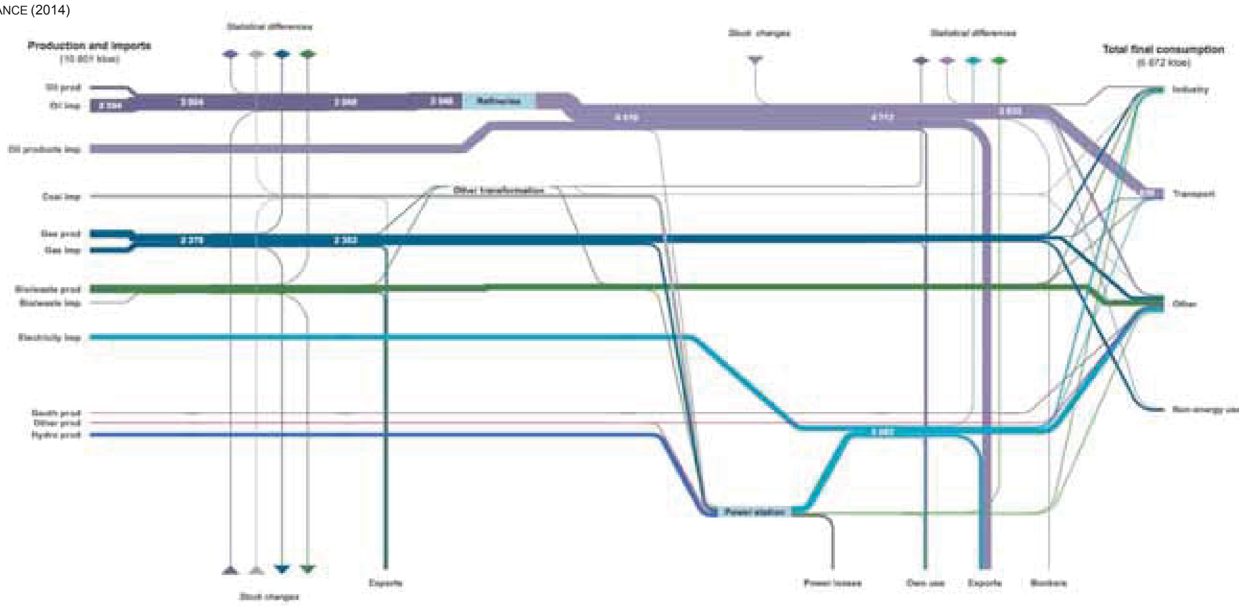


Fig. 146-147 Comparison of the final energy consumption in Slovenia in 1990 and 2014 (source: International energy Agency)

Croatia
Balance (2014)

Thousands of tonnes of oil equivalent



Croatia
Balance (1990)

Thousands of tonnes of oil equivalent

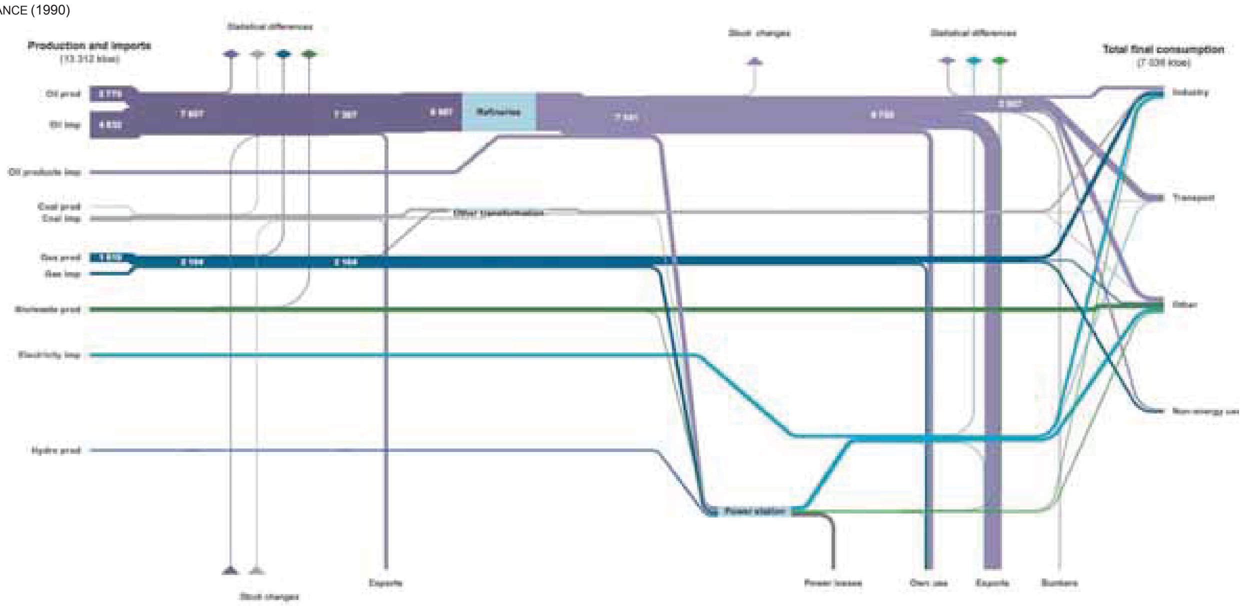
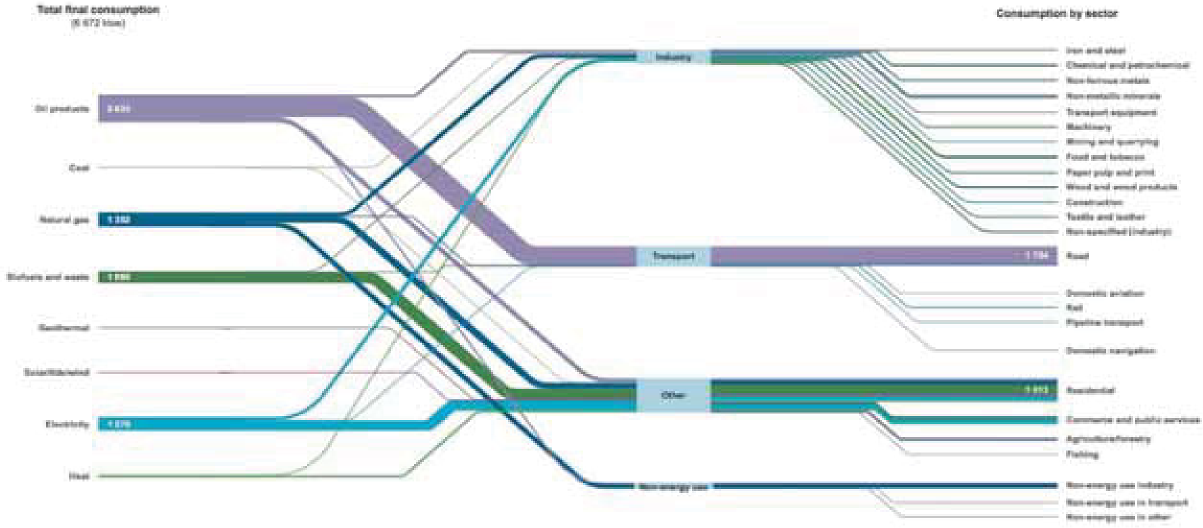


Fig. 148-149 Comparison of the energy balance in Croatia in 1990 and 2014 (source: International energy Agency)

Croatia

FINAL CONSUMPTION (2014)

Thousands of tonnes of oil equivalent



Croatia

FINAL CONSUMPTION (1990)

Thousands of tonnes of oil equivalent

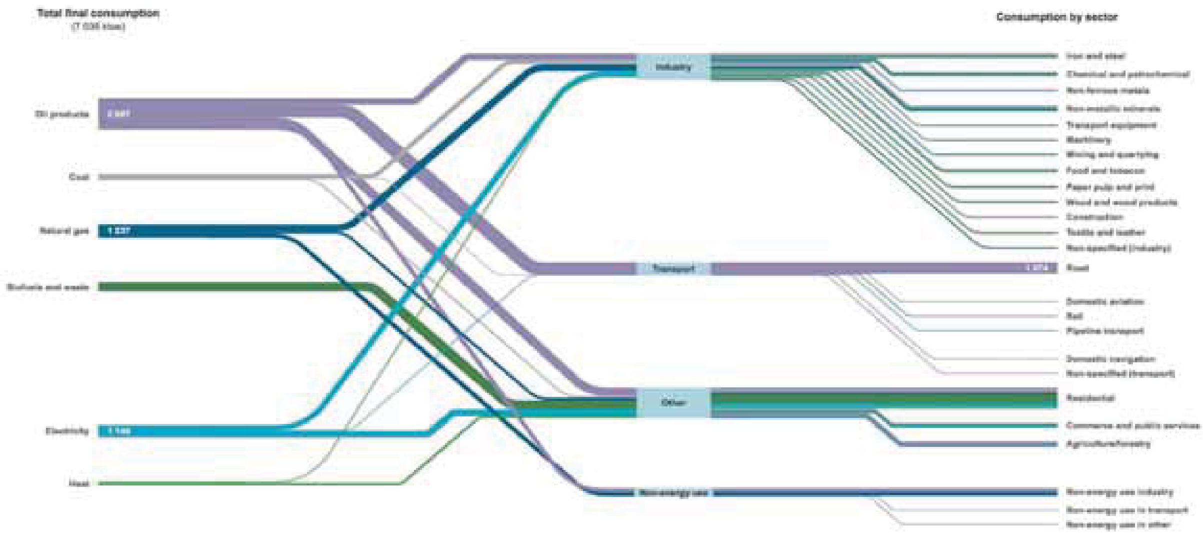
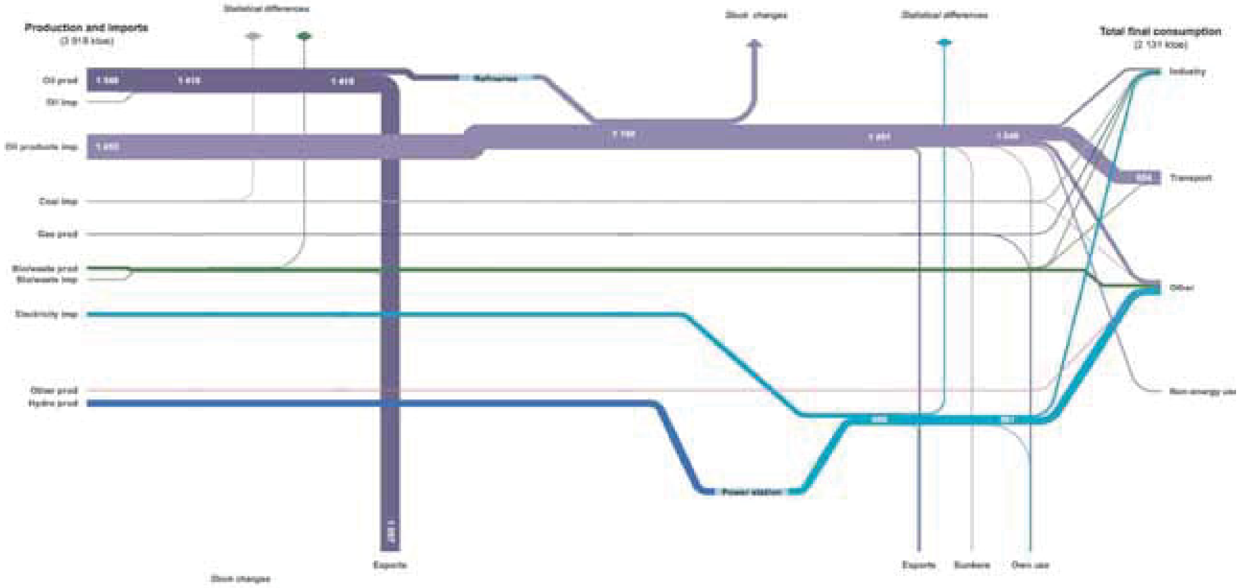


Fig. 150-151 Comparison of the final energy consumption in Croatia in 1990 and 2014 (source: International energy Agency)

Albania

BALANCE (2014)

Thousands of tonnes of oil equivalent



Albania

BALANCE (1990)

Thousands of tonnes of oil equivalent

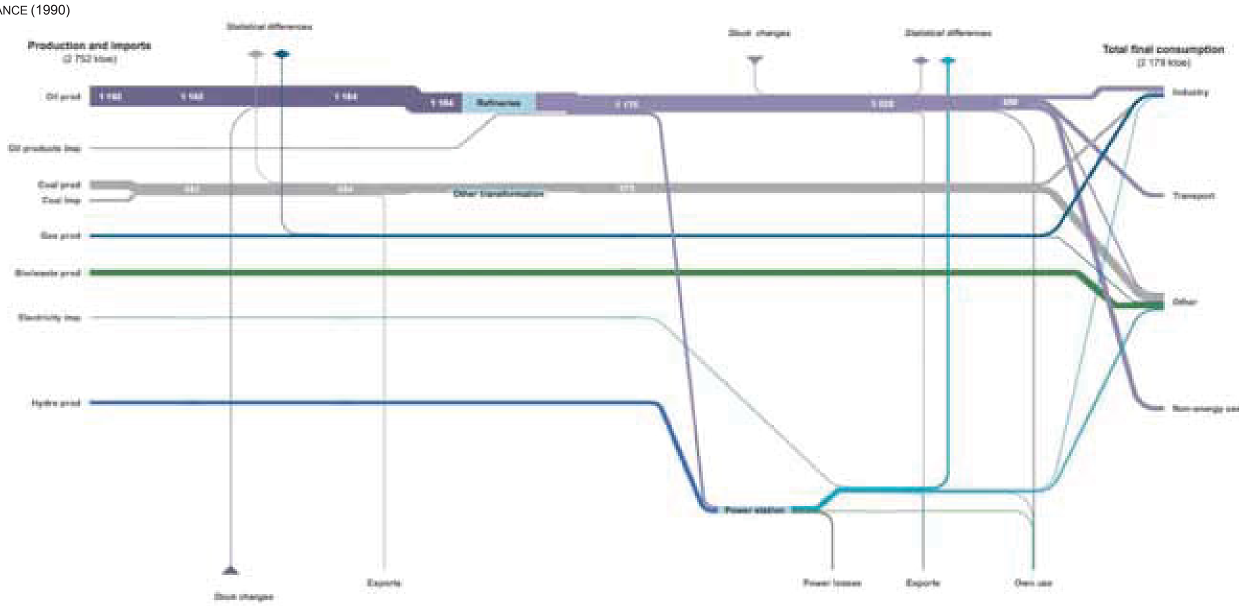
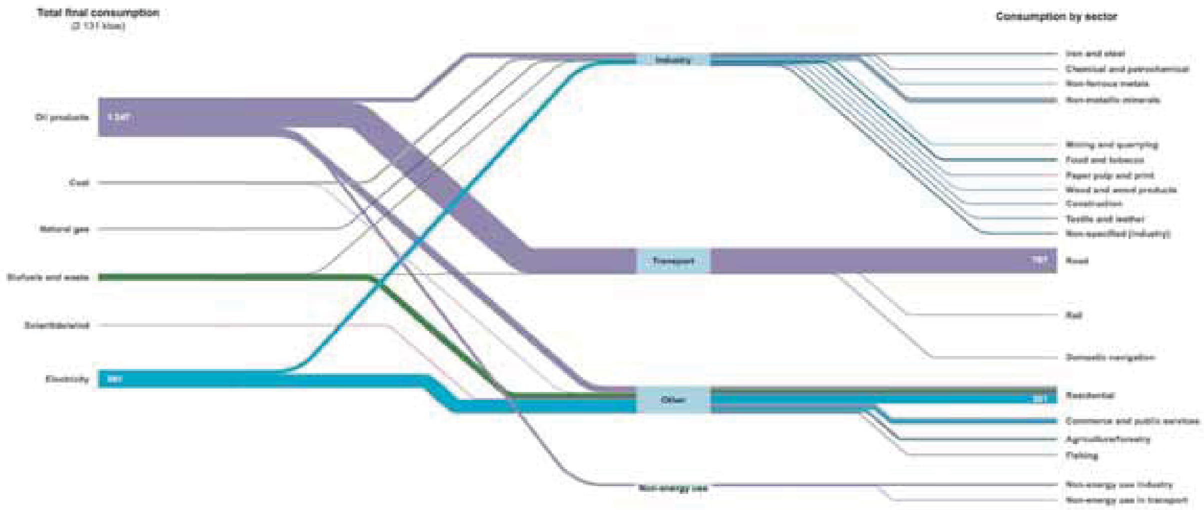


Fig. 152-153 Comparison of the energy balance in Albania in 1990 and 2014 (source: International energy Agency)

Albania
FINAL CONSUMPTION (2014)

Thousands of tonnes of oil equivalent



Albania
FINAL CONSUMPTION (1990)

Thousands of tonnes of oil equivalent

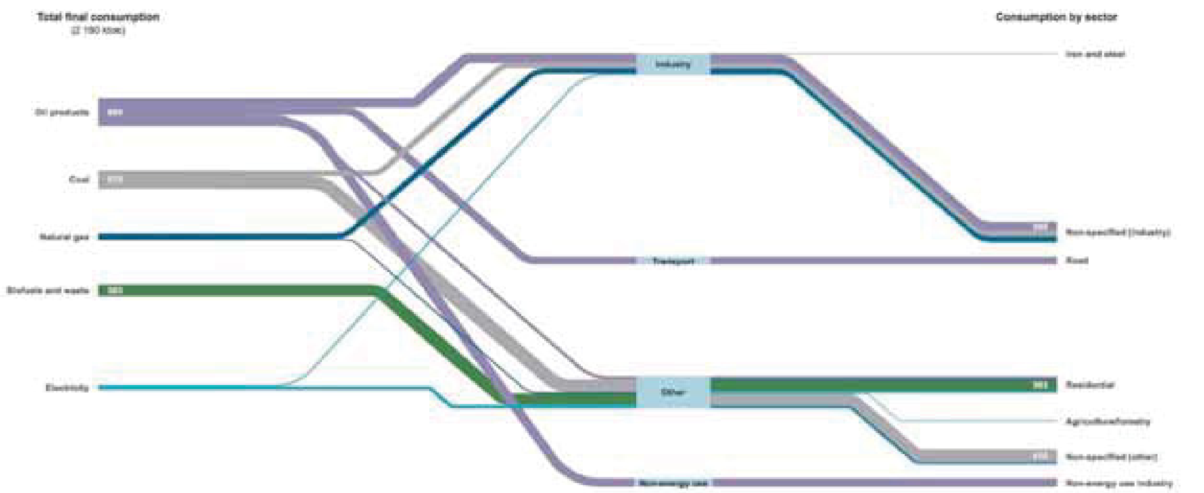
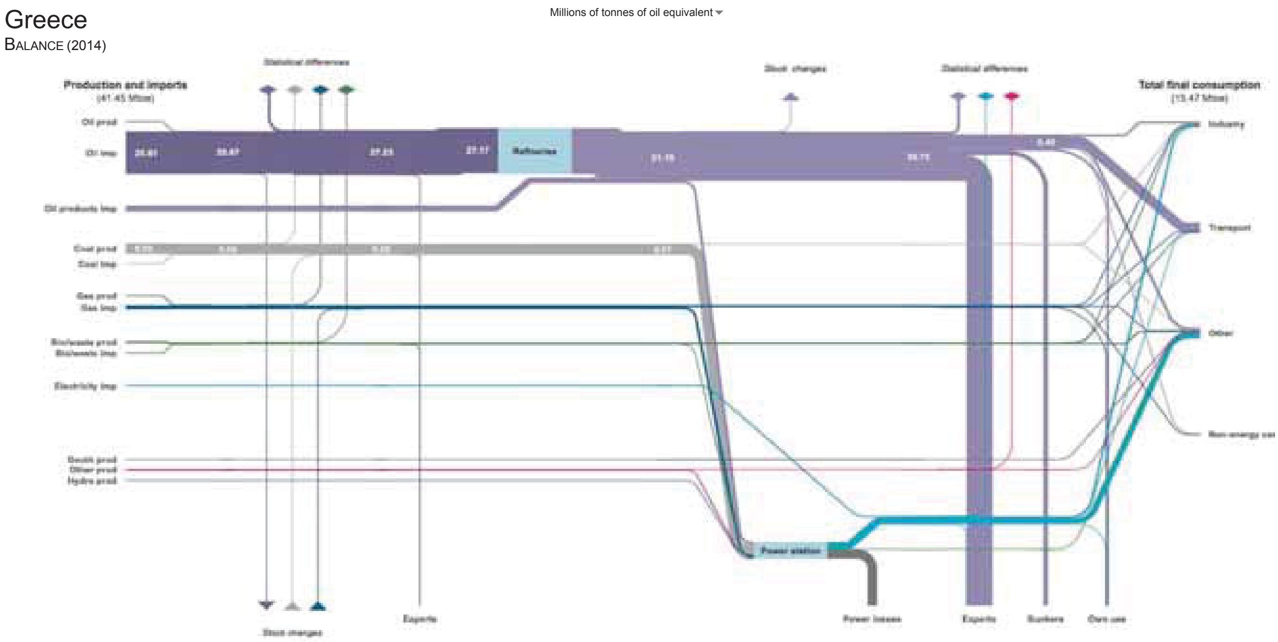


Fig. 154-155 Comparison of the final energy consumption in Albania in 1990 and 2014 (source: International energy Agency)



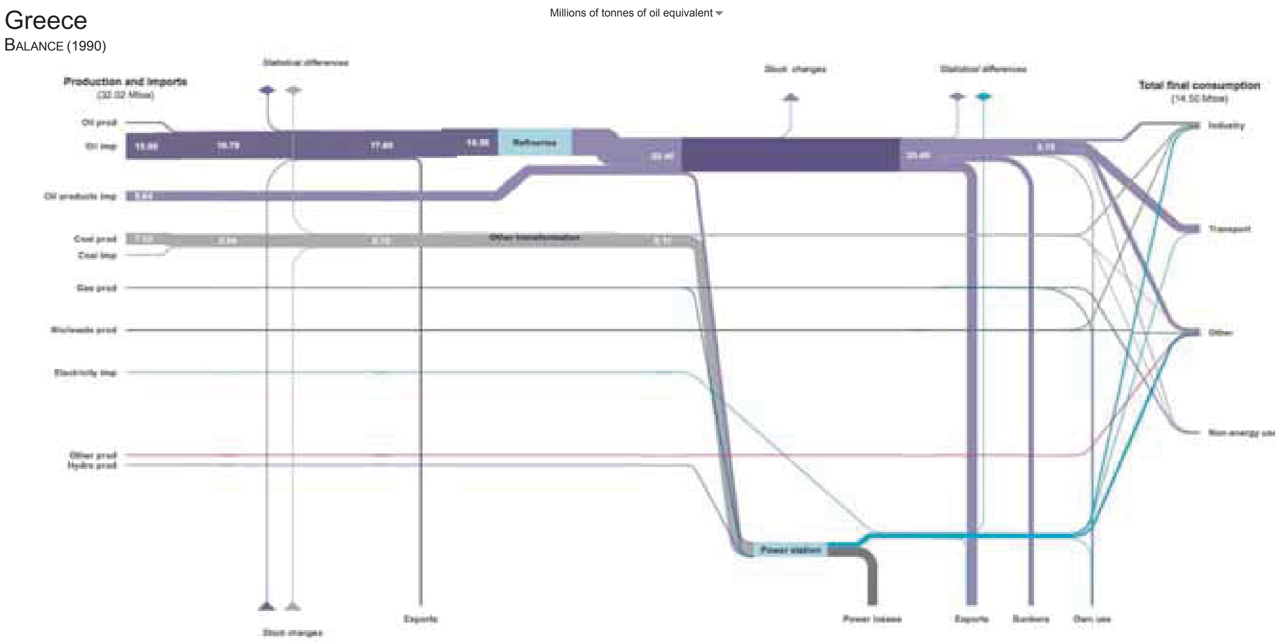
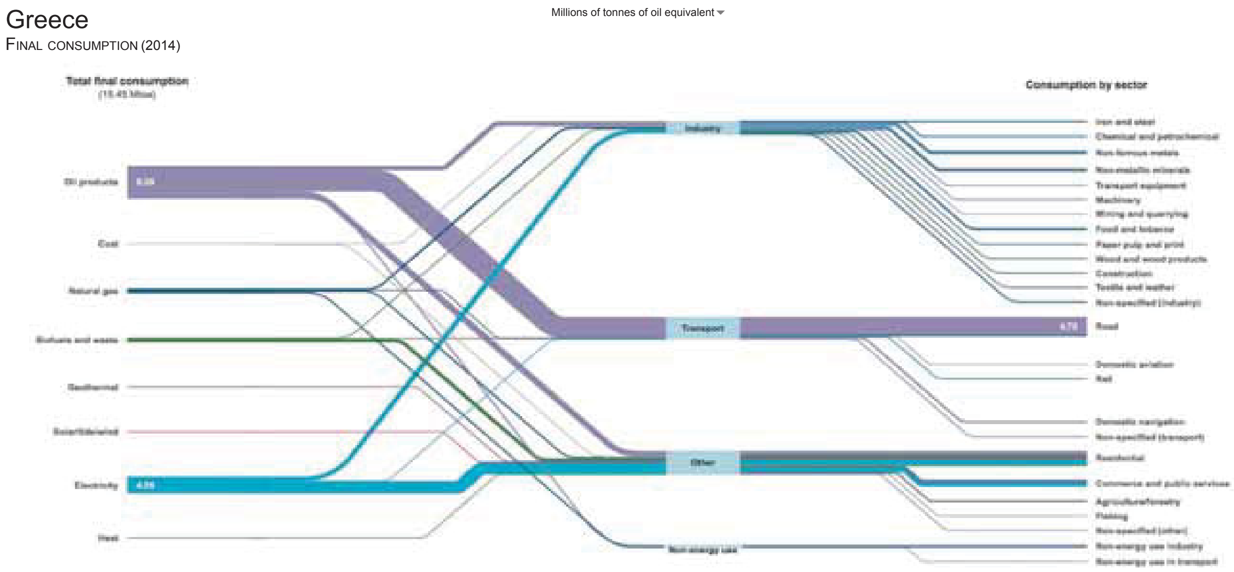


Fig. 156-157 Comparison of the energy balance in Greece in 1990 and 2014 (source: International energy Agency)



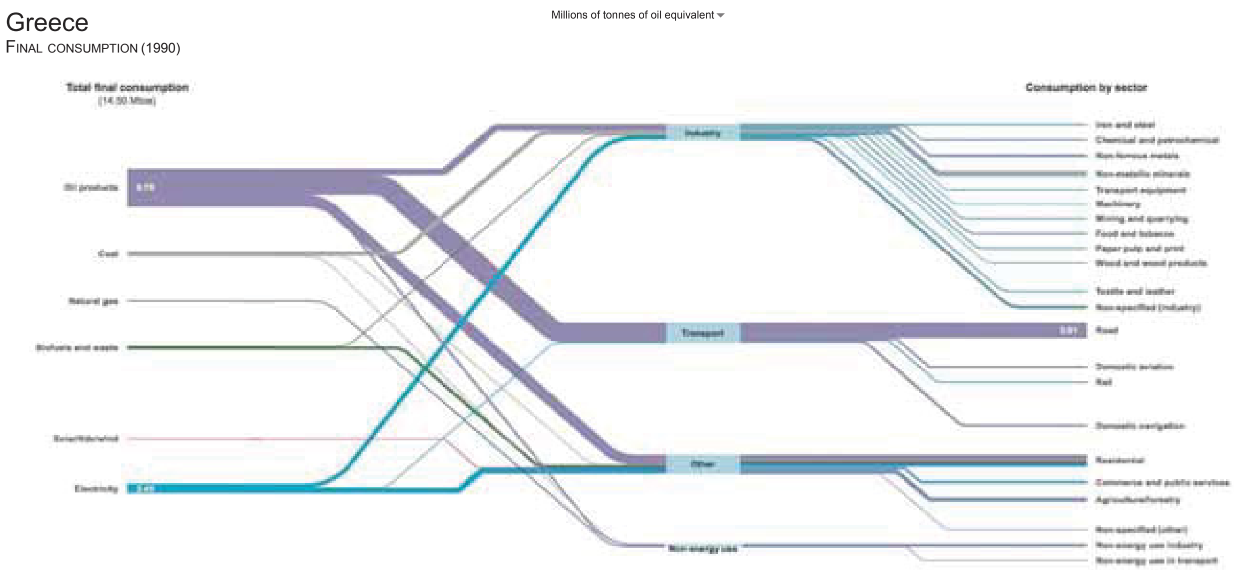


Fig. 158-159 Comparison of the final energy consumption in Greece in 1990 and 2014 (source: International energy Agency)

EUSAIR criticalities regarding Adrion region's energy future

what is EUSAIR

EU Strategy for the Adriatic-Ionian Region[1] is a macro-regional strategy adopted by the European Commission and endorsed by the European Council in 2014.
The main aim of the strategy is to create synergies and to encourage cooperation among all the countries belonging to the Adriatic-Ionian Region, in order to promote economic and social prosperity and growth in the region by improving its attractiveness, competitiveness and connectivity. In addition, western Balkans could take advantage of the implementation of the strategy for their gradual integration into the dynamics and policies of the European Union. Indeed, cooperation between EU Member States and non-Member ones could offer the opportunity to work alongside on domains of common interest.
EUSAIR is structured on four thematic pillars:

- Blue growth;
- Connecting the region (transport and energy networks);
- Environmental quality;
- Sustainable tourism.

With regard to the theme of our research, it is certainly the second pillar that interests us most and that we will go into in depth to understand which are the strategic actions defined by the European Union to achieve the objectives set.

Pillar 2: Connecting the Region (transport and energy network)

The general objective of the second pillar is to encourage infrastructure connectivity among the States of the Adrion region and with the rest of Europe, looking with particular interest at the development of transport and energy infrastructure. A fundamental aspect for the implementation of this desired infrastructural development consists in sharing a vision for a transnational territorial development and for a meticulous coordination for the trans-regional planning of infrastructural works.
As we have already seen, the macro-region is made up of countries with completely different political and historical frameworks, which have contributed to exacerbating disparities in terms of infrastructural development. The improvement and completion of transport and energy infrastructure becomes a necessary pre-condition to imagine a more balanced economic development and a more profitable social exchange between the different regions.
In the light of the renewed common ecological conscience, the environmental impacts associated with the construction of this infrastructure must be carefully weighed up, with the aim of integrating the sustainable planning on a larger scale.

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1 see http://www.adriatic-ionian.eu/component/edocman/34-action-plan-eusair-pdf, the Commission Staff Working Document - Action Plan - Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions concerning the European Union Strategy for the Adriatic and Ionian Region (Brussels 17.06.2014)

New sustainable transport axes and an efficient intermodality will bring benefits and new investments in tourism and freight transport, bringing the northern Adriatic region back to its original role as gateway to central and eastern Europe. At the same time, a better interconnected energy networks will benefit the whole south-east Europe region and contribute to the transition from the current predominant oil and coal energy production towards more sustainable energy sources.
Investments in transports and in energy networks could enhance small and medium enterprises which are by nature the most inclined actors to search for new solutions to be placed on the market and would favour investments, thus growth and jobs.

Three are the main infrastructural topics on which the pillar will focus on:

- *Maritime transport*, to develop a competitive regional intermodal port system;
- *Intermodal connections to the hinterland*, in order to develop a widespread and intermodal metwork for freight and passengers;
- *Energy networks*, to achieve an internal energy market supporting the three EU policy objectives (competitiveness, security of supply and sustainability).

The actions within the three topics must be coordinated according to the vision and planning of the macro-region and integrated with the development lines defined by the European Union for the main transport (TEN-T, Trans-European Networks for Transport) and energy (TEN-E, Trans-European Networks for Energy) axes.

EUSAIR's criticalities about energy network

If we now look at the strategies suggested in the EUSAIR Action Plan about regarding *energy networks*, we see at once that the focus is mainly on two principal infrastructural improvements:

- the development of electricity grid interconnections and the adaptation of grids capacity constitute fundamental pre-condition for large-scale investments in renewable energies;
- the development of the natural gas network in the Balkan countries (Trans Adriatic Pipeline – TAP, and the Ionian-Adriatic Pipeline - IAP), which currently lack of supply from major gas pipelines coming from reserves in Russia and Azerbaijan.

Although the strategy of investing in natural gas infrastructure is proposed by EUSAIR action plan as a real improvement in environmental terms, and certainly it is, we believe that this type of strategic documents which envisage to define the vision of a macro-regional territorial development should have a much longer and much more disruptive focus than proposing traditional practices. The reduction of environmental impacts due to the spread of gas pipelines does not, however, solve the energy dependence on fossil fuel resources, and above all the energy dependence on supplying geographical areas, which, as we have seen, contributes in accentuating the economic imbalances which are at the origin of several armed conflicts of the XX century. A real sustainable economic and social improvement would be achievable if we completely detached from fossil fuel energy supply and encouraged the development of that distribution and storage infrastructure for energy resources which are democratically distributed in each country. The most recent research is encouraging the development of innovative and alternative technologies such as hydrogen, carbon dioxide capture and storage and energy production from micro and macroalgae.

EUSAIR completely lacks any indication that could direct actions and projects towards these disruptive horizons and, from our point of view, is an incredible missed opportunity.

The energetic transition will not happen overnight, and it will be necessary to initiate a cultural change, as we have already seen, in the automotive industry so as to free it from dependence on 50-75% of domestic oil consumption. Precisely because the transition is not immediate, and at the same time in order not to arrive too late, we must start preparing territories now with infrastructure of tomorrow. According to Rifkin, fifty years have been necessary to provide the territories with the oil infrastructure needed for the second industrial revolution. It is likely that the re-use and completion of the existing energy infrastructure networks through renewable energy sources could help to drastically reduce the transition times, but it is necessary to define the zero day from which to start the transition in a synergic and coordinated way.

In the next paragraph we will take stock of the state of research and of the potential of these disruptive energetic horizons.

Disruptive energetic horizons

algae for the energy quest

Alternative renewable sources for energy production are more and more drawing the attention of research centres, universities and private companies to evaluate their technical feasibility, productive efficiency and economic competitiveness. Among them, *algae cultivation for energy production* is revealing to be a very versatile technology with a huge potential yet to be explored. First attentions towards large-scale algae cultivation date back to the World War II in Germany, but the very first publication was edited by J. S. Burlew (1953). More recently, research interest shifted towards algae potential for the energy quest. In recent decades, the European Commission has also demonstrated to be a very interested stakeholder for the application of industrial algae cultivation technologies, financing many project proposals for the use of algae in the energy, pharmaceutical, cosmetics and nutraceutical sectors.

Basically, algae are very simple and versatile photosynthetic organisms, which rapidly grow in several environmental water conditions and feed on carbon dioxide. Their chemical composition allows obtaining a biomass rich in carbohydrates, lipids, proteins, metabolites and hydrogen, so making algae very flexible towards several applications and uses in very different domains. Algae have some remarkable characteristics that result to be very interesting, and, according to Mazzitelli (2010), can be listed as follows:

- algae have a high productivity of biomass and of convertible lipids per unit of cultivated area, which means that land use is more efficient than agricultural biomass production;

CULTIVATION	OIL YIELD (liter/ha) (% algae)	CULTIVATED NECESSARY AREA (Mha) to meet 50% of fuel consumption in the USA
WHEAT	172 (0.29)	1540
SOYBEANS	446 (0.76)	594
COLZA	1190 (2.03)	223
JATHROPA	1892 (3.22)	140
COCONUT	2689 (4.58)	99
PALM	5950 (10.14)	45
MICROALGAE 70% weight/weight of oil in the biomass	**136900 (233.2)**	**2**
MICROALGAE 30% weight/weight of oil in the biomass	**58700 (100)**	**4.5**

Table 2 Comparison of lipid productivity between microalgae and some sources of biomass (source: Mazzitelli, 2010)

- the non-competitiveness with agri-food industry because algae are capable to grow in extreme conditions which are not suitable for agricultural purposes;
- the consequent economic and energetic valorization of non-productive lands (deserts, non-fertile lands, seawater, etc.) if treated with algae cultivations;
- their versatility to adapt and grow in several different aquatic environments (saltwater, fresh water, brackish water, urban wastewater);
- their compatibility with fossil fuel refining infrastructure because algae fuels have similar properties to fossil ones, but they are zero carbon emissive;
- the possibility of combining energy production with algae by-products for nutraceutical, aquaculture, biofertilizers, cosmetics industry, in order to generate a high value added and to reduce the cost of energy production;
- a contribution to CO_2 emissions reduction as algae absorb large amounts of carbon dioxide during the photosynthesis process to produce oxygen;
- the possibility of integrating algae energy production with other industrial processes, such as with wastewater treatment plants;
- their high energy value, which, according to Sijmons (2014) is very similar to lignite's one (20MJ per kilogram of dry substance).

In order to complete the general overview about the current state of art of algae energy and electricity production, it is worth to deepen some technical aspects, thanks to a chemical and engineering literature and to some EU funded projects. In particular, we are going to deepen some biological and engineering aspects, such as follows:

- algae classification and energetic productive species;
- algae mass cultivation systems;
- energy conversion techniques;
- implementation of algae cultivation with existing industrial processes.

algae classification

First of all, algae can be divided in two main groups according to their size: *micro-algae* and *macro-algae*.

Micro-algae are infinitesimal, primitive tallophytic plants, with no roots, stem and leaves, capable to adapt to multiple ecosystems in a wide range of salinity, temperature and pH levels. As seen in the table above, micro-algae are characterized by high biomass and lipid productivity and are also extremely reactive in carbon dioxide absorption during photosynthesis.

To name just a few of the most suitable micro-algae species for energy purposes, we can mention *Botryococcus Braunii*, C*hlorella* and *Dunaliella*.


Fig. 160 Botryococcus Braunii (source: Wikipedia)

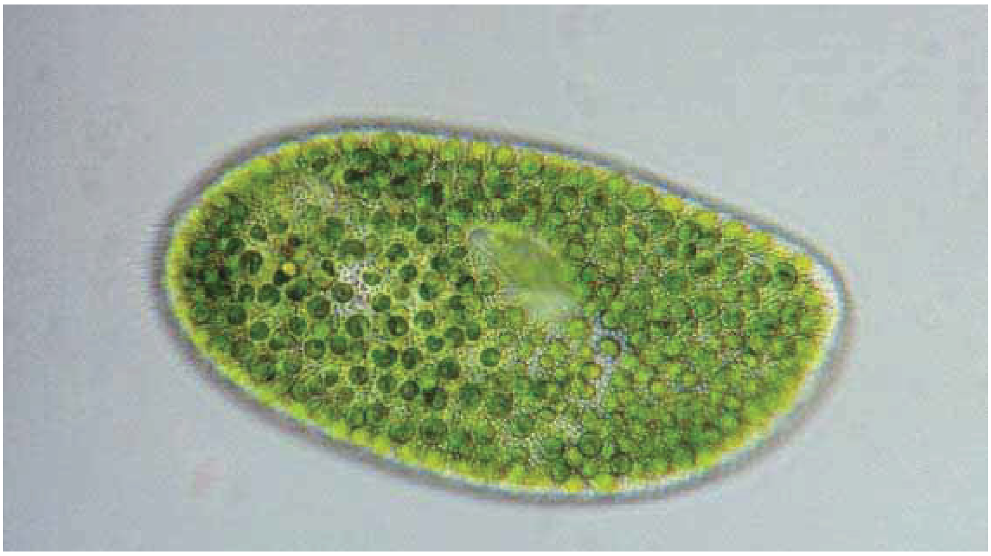
Fig. 161 Chlorella (source: Huffington Post)


Fig. 162 Dunaliella (source: Wikipedia)

Certain environmental conditions have a positive impact and speed up the algal biomass growth, for example:.

- *carbon absorption,* in fact algae can tolerate a concentration of CO_2 until 150.000 parts per million volume (in spite of 360 ppmv that are normally in the air);
- *light intensity,* up to a saturation point beyond which growth collapses;
- *slight turbulences*, which, keeping algae in suspension, improve light efficiency, gas exchanges and nutrients distribution;
- *temperature control*, which should normally be comprised between 10 and 30 degrees above the ambient temperature;
- *nitrogen starvation*, which consists in a low nitrogen supply which induces higher production of lipids as a defence reaction to the stressful conditions to which they are subjected, but at the expense of biomass volume production;

Macro-algae, or seaweed, are principally classified according to their pigment content: *brown*, *red* and *green*. They are normally cultivated for nutritional purposes, in particular in Far East Asia, and they generate a very profitable and fervent economic activity. Some of the most popular macro-algae species are *Saccharina Japonica* and *Gracilaria Sargassum*.

Fig. 163 Saccharina Japonica (source: http://www.seaweed.ie/aquaculture/kelp_china.php)

algae mass cultivation systems

Two are the principal techniques for *micro-algae mass cultivation*:

- *open raceway ponds*, which are normally composed by circular channels where the cultivation broth is reflowed and mixed by means of a rotary shovel near which cultivation is continuously fed. In order to limit anaerobiosis and the consequent loss of biomass weight, open raceway ponds' width is limited to 30 cm. The absorption of pumped carbon dioxide in open systems is limited;
- *photo-bioreactors*, which consist in closed environments where the cultivation broth can be kept constantly in motion (specially in helical tubes) and is protected by external agents, thus preventing from a reduction of algae productivity. Photo-bioreactors are composed by a set of plastic or glass tubes with a maximum diameter of 20 cm. They can be north-south oriented and possibly inclined in order to maximize solar radiation, but even other configurations (horizontal, vertical, helical) work anyway. Biomass is kept in motion by airlift pumps, while the oxygen generated by photosynthesis has to be removed because it reduces biomass productivity. Thus, biomass path in photo-bioreactors does not normally exceed 80 m length before encountering a zone for O_2 removal.

Fig. 164 Open raceway ponds (source: Researchgate)

Fig. 165 Photo-bioreactors (source: Wikipedia)

Macro-algae are generally cultivated through extensive off-shore systems, which require algal grafts to ropes or similar supports, so occupying large open sea surfaces. This is a cultivation technique which shows some limits, in fact nutrients supply in an open system is difficultly controllable and weather conditions strongly affect the productivity. Moreover, large algae monoculture plantations are more easily subject to the spread of contaminating pathogens.

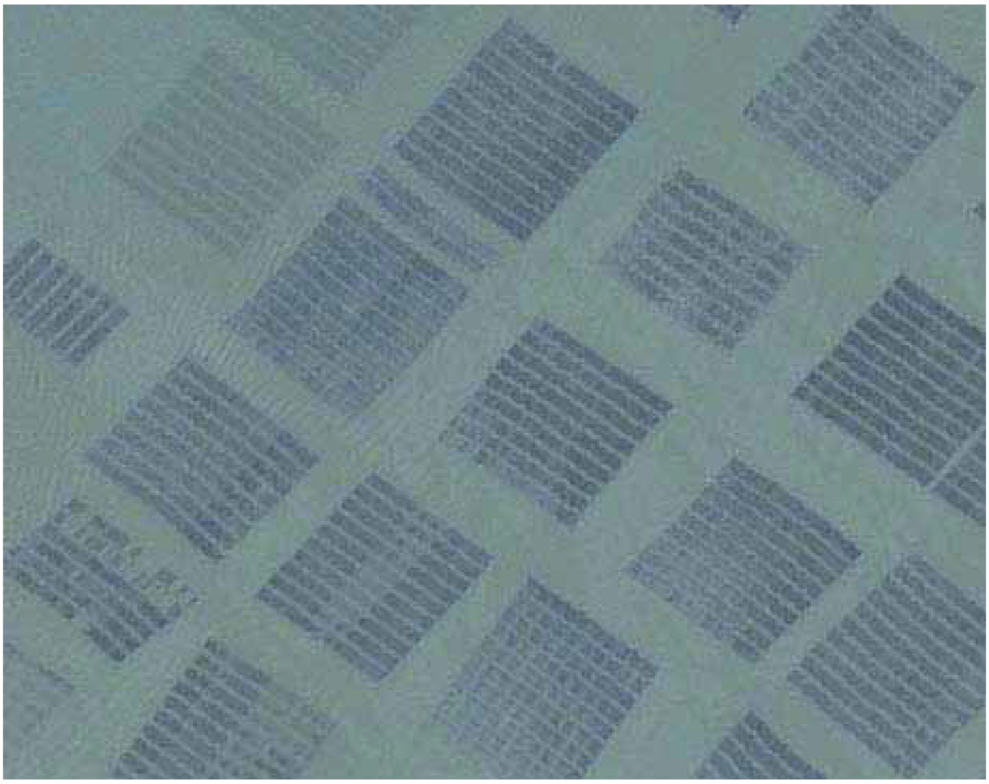

Fig. 166 Aerial view of a seaweed farm in the Chinese province of Jiangsu, south of the city of Qingdao (source: Bing Maps)

Fig. 167 Seaweed farm in Zanzibar (source: https://commons.wikimedia.org/wiki/File%3ASeaweed_farm_uroa_zanzibar.jpg)

energy conversion techniques

The high water content and the low concentration of biomass in cultivation broths (between 0.05 and 5 kg/m^3) are the most relevant compelling factors in the choice of energy conversion techniques. It is therefore necessary to combine different processing stages for the recovery and drying of algae biomass in order to minimize the impact of these steps on costs and efficiency. Another important factor to consider is that the type of downstream process defines the type of energy obtained.

If we first consider *micro-algae* processing, an important aspect to take into account is that downstream could represent until 30% of global biomass production costs because of the difficulty to recover biomass in cultivation broth. Biomass concentrations are extremely low (from 0.3 up to 5 g/l) and micro algae dimensions are reduced (between 2-40 μ).
In order to have a general overview about the different possibilities for microalgal biomass recovery, the most commonly used techniques are as follows:

- *flocculation,* which allows to aggregate micro-algae particles through the use of some cationic chemical agents, such as metal salts;
- *floatation*, which entails the introduction of air into the treatment basin;
- *sedimentation*, which works very well by gravity in case of huge water volumes and low biomass concentration, but it is not very adequate for micro-algae processing because of their reduced size;
- *centrifugation*, which is a very efficient technique, but at the same time very onerous in terms of energetic consumption;
- *filtration,* which is normally combined with flocculation in case of infinitesimal micro-algae and is a high energetic costs technique.

Once the biomass has been separated from the cultivation broth, the treatment shall proceed to the drying stage of the biomass. This phase is very important because the type of drying influences the type of energy that can be produced:

- *dehydration* is one of the possible methods and it functions through solar exposition of semi-liquid biomass or though ventilated air in closed recipients. Drying by convection is an interesting solution when the heat of combustion fumes from electrical power plants is used;
- another common drying technique is *extraction and fractionation* and consists in a pair of solvents which are mixed with the dried biomass and one of them intervenes on cells' membrane to make them more porous and the other one operates in order to extract lipids.

Depending on the type of final by-product it wants to be obtained (biofuel or electric energy), the dried biomass can be treated through *thermochemical* or *biochemical* conversion processes.

Among the *thermochemical conversion techniques,* it is worth mentioning the following processes:

- *gasification* normally converts organic matter in gas (methane) through a partial oxidation by means of high temperature steam (800-900°C);
- *liquefaction* allows obtaining gas and fuel oils and it happens in a water solution with alkaline salts at about 300°C and 10Mpa;
- *pyrolysis* is a technique that converts biomass in biofuel, char and in a gaseous fraction (syngas). Biomass is exposed to different heating speeds, creating different types of by-products which are distributed according to their degree of cracking. Pyrolysis needs dry biomasses and, depending on the rapidity of processes, it can be classified in slow, fast and flash pyrolysis. *Slow pyrolysis*, operated at slow heating speeds, involves lower production of liquids and gases in favour of greater bio-char production. *Fast pyrolysis* allows heating speeds comprised between 300-600°C and is capable to generate high yields of oil (up to 68%). *Flash pyrolysis* takes a few seconds to react and requires very small particle processing. The biofuel obtained from pyrolysis has very similar properties to fossil fuels ones.

Biochemical energy conversion contained in micro-algae implies the transformation of lipids and polysaccharides and the most common techniques are:

- *transesterification* is used in order to convert the triglycerides extracted from micro-algae and to reduce oil viscosity;
- *anaerobic digestion* transforms residues from lipid extraction in methane fuel gas.

The main by-products of biochemical conversion processes are biodiesel and ethanol. In terms of efficiency for ethanol production, it is interesting to notice that the most efficient agricultural cultivation is sugar cane, with 7.5 m^3/ha, which is largely inferior to micro-algae production, with 100 m^3/ha (Chisti, 2008).

implementation of algae cultivation and processing with existing industrial sites

The great versatility of micro-algae and the possibility to obtain several high value added by-products, together with energy production, encourage the opportunity to integrate industrial micro-algae production systems to other existing industrial sites, bringing economic and environmental benefits to both.
One of the possible integrations could be envisaged with power plants through *Carbon Capture technology*. The carbon dioxide emitted by power plants' activities and captured by this innovative technology can be conveyed and then absorbed by micro-algae during their photosynthesis process and it contributes to a significant and rapid growth of algae biomass. Thus, the integration of micro-algae production together with Carbon Capture and Storage technology to

existing industrial sites goes in the zero emission direction of fossil fuel power plants (Douskova et al., 2009) and could even reduce the emissions of NO_x in industrial fumes (Nagase et al., 1998).
Another possible and interesting synergy of industrial algae cultivation could be found with water treatment plants. Micro-algae growth in water treatment basins could contribute to the removal of contaminants by dissolving the oxygen produced during the photosynthesis process, and, at the same time, by assimilating nutrients, which could be boosted by insufflating CO_2 in the system.

algae biorefinery

The notion of *algae biorefinery* stands for the forthcoming evolution of traditional oil refineries towards a bio-based economy. In fact, this new refining infrastructure, as seen before, lies on the possibility to integrate *carbon capture and storage* technology to industrial algae cultivation in translucent photo-bioreactors. The versatility of algae in obtaining several high value added by-products represents a central issue for the definition of a profitable business plan which could justify the current high investment for energy production. The consolidated and widespread uses of algae in cosmetics, pharmaceutical, nutraceutical and fertilizer industries confirm the profitability of algae by-products.
Some EU-funded project experiences during the 7th Framework Programme have focused on this topic and demonstrated the possibility of integrating algae refining with algae energy production, trying to maximize the profitability of algae residues from refining processes for energetic purposes.

The principal aim of the EU-funded project *MIRACLES*[1] was to estimate the life cycle assessement and the socio-economic impact of microalgae biotechnology implementation as a sustainable production platform for food and non-food products. One of the most interesting results obtained is that algae residues can be used to produce huge amounts of *Glycerol*, so enhancing the implementation of bio-chemical industries for the production of bio-polymers, with an alternative technology to the current production of bio-plastics by corn which results to be extremely impacting in term of land consumption and competitive to corn crops for the food industry.

Other interesting results concerning the potential of algae by-products were presented by the EU-funded research *BISIGODOS*[2], which explores the possibility to obtain bio-resins for coatings, printing, food, hair care and adhesive

1 *MIRACLES (Multi-product Integrated bioRefinery of Algae: from Carbon dioxide and Light Energy to high-value Specialties)* is a 4-year project (2013-2017) funded by the EU under the FP7 - KBBE - Specific Programme Cooperation: Food, Agriculture and Biotechnology. (see www.miraclesproject.eu)

2 *BISIGODOS (High value added chemicals and BIoreSIns from alGae biorefineries produced from CO_2 provided by industrial emissions)* is a EU-funded project under the FP7 - KBBE - Specific Programme Cooperation: Food, Agriculture and Biotechnology. (see www.bisigodos.eu)

applications, starting from algae biomass fed directly with CO_2 coming from heavy industrial activities and thermal power plants.

PUFAChain[3] project investigated on the high value added chain of high purified Omega-3 fatty acids (DHA/EPA) obtained from algae processing as building blocks in modern oleo chemistry for nutrition and pharmaceutical applications.

A key experience for the implementation of the notion of algae biorefineries is represented by the ongoing EU-funded project *D-FACTORY*[4], a micro-algae biorefinery which aims to set a world benchmark in the establishment of a CO_2-algae synergy and which processes Dunaliella salina biomass.
The project foresees to integrate different methods of microalgae cultivation on the same time, so combining open raceway ponds with photo-bioreactors. The D-factory project wants to test some innovative techniques in biomass cultivation and processing technologies, such as the pumping of supercritical carbon dioxide in order to enhance biomass growth and the use of membranes to produce carotenes and other bioactive compounds, emulsifiers and polymers.

Fig. 168 MIRACLES project: different types of algae cultivation (source: MIRACLES project)

Fig. 169 D-FACTORY project: open raceway ponds (source: D-FACTORY project)

3 *PUFAChain (The Value Chain from Microalgae to Poly Unsaturated Fatty Acids) is a EU-funded project under the* FP7 - KBBE - Specific Programme Cooperation: Food, Agriculture and Biotechnology (see www.pufachain.eu)
4 *D-FACTORY (THE MICRO ALGAE BIOREFINERY) is a EU-funded project under the FP7 - KBBE.2013.3.2-02 - The CO2 algae biorefinery (see www.d-factoryalgae.eu)*

carbon capture and storage (CCS) or re-use (CCU) technology

As well known, the challenge envisaged by COP 21[5] is ambitious, but necessary: the objective is to keep the increase in global warming below 2°C if compared with pre-industrial levels and to limit it at 1,5°C up to 2050.

According to IEA (International Energy Agency, 2013), our current global economy is still fossil fuels-driven and it will probably take some further decades to witness to a structural and massive shift towards a bio-based economy. Thus, no climate friendly scenario is foreseeable without the integration of *Carbon Capture and Storage* technology (CCS) to power plants and to highly-CO_2 emitting industrial sites. IEA is convinced that a rapid scale-up of CCS technology could contribute in reducing one-sixth of CO_2 emissions by 2050, which correspond to a 14% decrease of cumulative emission reductions between 2015 and 2050 if compared to a standard growth scenario, which would lead to an increase in global average temperature of 6°C. Therefore, CCS is an innovative technology capable of capturing up to 90% of the carbon dioxide contained in industrial emissions.

In 2011, seven large industrial sectors (including cement, iron and steel, chemicals and refining) have released into the atmosphere about 7 $GtCO_2$, that corresponds to one-fifth of the total of 31 $GtCO_2$ emitted globally. According to current growth trends, policies and needs, CO_2 emissions are not going to fall down in the short term, but on the contrary carbon dioxide emissions coming from previous industrial sectors are expected to grow by around 35% up to 2050 (IEA, 2013). The growth of modern economies is still based on commodities such as steel, cement, fuels and chemicals and this will not contribute to diminishing CO_2 emissions.

As a consequence of fact, CCS technology should break the tight relationship between economic growth and the increasing of CO_2 emissions.

Afterwards, we are going to provide a quick overview about the functioning of CCS technology, which mainly consists of three activities: CO_2 capture, transport and storage (or re-use).

CO_2 capture

Three are the methods to separate and capture carbon dioxide from other gases coming from fossil fuels combustion during industrial processes:

pre-combustion capture, *post-combustion capture* and *oxyfuel combustion*.

Pre-combustion system is characterised by the use of *gasification* or *reforming* techniques to convert solid, liquid or gaseous fuel into a mixture of hydrogen and carbon dioxide which can be further stored or re-used for integrated industrial

5 The 2015 United Nations Climate Change Conference (COP 21) was held in Paris, France, from 30 November to 12 December 2015. It was the 21st yearly session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Conference of the Parties (CMP) to the 1997 Kyoto Protocol. The Paris Agreement was the outcome of the COP 21, signed by 194 countries, dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020.

processes or for electrical purposes.
Post-combustion capture consists of a CO_2 recovery from the exhausted emissions of a combustion process by absorbing it through a suitable solvent. Then, CO_2 is separated from the solvent and compressed for transportation and storage.
Carbon dioxide separation is carried out using different techniques, such as *high pressure membrane filtration*, *adsorption/desorption processes* and *cryogenic separation*.
Oxy-fuel combustion is a process through which oxygen is separated from air before combustion and fuel is combusted in oxygen diluted with recycled flue-gas rather than air.

The main sources of carbon dioxyde are generally related to industrial activities based on fossil fuel combustion as power plants are, but even other industrial processes (steel, cement, chemicals, oil refining) are great producers of carbon dioxide. Depending on the origin of CO_2, the stream could contain H_2O, N_2, O_2, H_2S and CO. These chemical components could negatively affect on CO_2 transport efficiency and on the integrity of transport infrastructure, so that they have to be separated and removed from the stream before entering the pipelines.

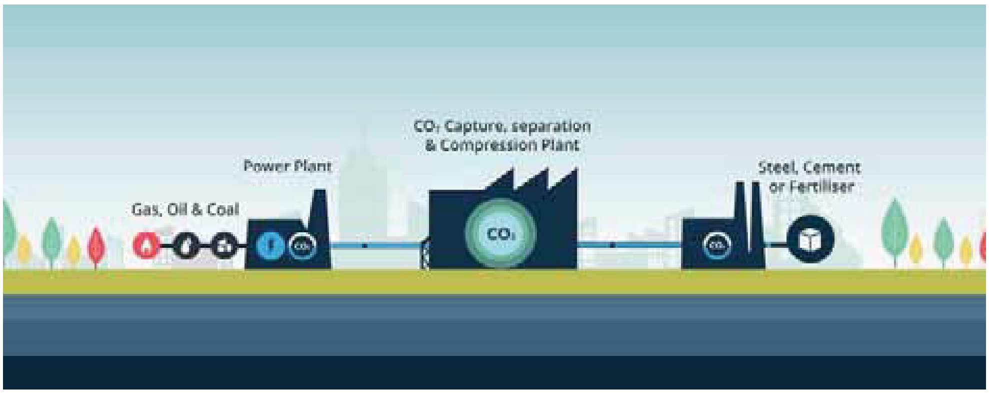

Fig. 170 CO_2 capture (source: co2degrees.com)

CO_2 transport

Current CO_2 ways of transport are the same used for fossil fuels, that is to say that carbon dioxide is transported by ship, by road tanker or by pipelines. According to IEAGHG (International Energy Agency GreenHouse Gases, 2013), it seems that more than 6'500 km of specific CO_2 pipelines are spread all over the world and especially in the USA. Most of them are related to EOR (Enhanced Oil Recovery) activities, but some others have been developed for CO_2 storage purposes and for implementing greenhouses' productivity.
More than 80 carbon dioxide pipelines projects are in construction or have already been implemented worldwide, but we would like to take into consideration a selection of the 29 most remarkable projects of carbon dioxide infrastructure which are mentioned in the document published by IEAGHG in 2013.

PROJECT NAME	COUNTRY	STATUS	LENGHT (km)	CAPACITY (Mton/y)	ONSHORE OFFSHORE	SINK
CO_2 Slurry	CA	P	n/a	n/a	Onshore	EOR
Quest	CA	P	84	1.2	Onshore	Saline aquifer
Alberta Trunk Line	CA	P	240	15	Onshore	n/a
Weyburn	CA	O	330	2	Onshore	EOR
Saskpower	CA	P	66	1.2	Onshore	EOR
Beaver Creek	USA	O	76	n/a	Onshore	EOR
Monell	USA	O	52.6	1.6	Onshore	EOR
Bairoil	USA	O	258	23	Onshore	n/a
Salt Creek	USA	O	201	4.3	Onshore	EOR
Sheep Mountain	USA	O	656	11	Onshore	CO_2 hub
Slaughter	USA	O	56	2.6	Onshore	EOR
Cortez	USA	O	808	24	Onshore	CO_2 hub
Central Basin	USA	O	231.75	27	Onshore	CO_2 hub
Canyon Reef Carrier	USA	O	354	n/a	Onshore	n/a
Choctaw (NEJD)	USA	O	294	7	Onshore	EOR
Decatur	USA	O	1.9	1.1	Onshore	Saline aquifer
Snohvit	NO	O	153	0,7	Both	Porous sandstone
Peterhead	UK	P	116	10	Both	Depleted oil/gas field
Longannet	UK	C	380	2	Both	Depleted oil/gas field
White Rose	UK	P	165	20	Both	Saline aquifer
Kingsnorth	UK	C	270	10	Both	Depleted oil/gas field
ROAD	NL	P	25	5	Both	Depleted oil/gas field
Barendrecht	NL	C	20	0.9	Onshore	Depleted oil/gas field
OCAP	NL	O	97	0.4	Onshore	Greenhouses
Jänschwalde	DE	C	52	2	Onshore	Sandstone
Lacq	FR	O	27	0.06	Onshore	Depleted oil/gas field
Rhourde	DK	P	30	0.5	Onshore	Depleted oil/gas field
Oinshui	CN	P	116	0.5	Onshore	ECBMR
Gorgon	AU	P	8.4	4	Onshore	Sandstone

Table. 3 CO_2 pipeline projects (source: IEAGHG, 2013)

Several are the drivers for implementing CO_2 pipelines:

- *Enhanced Oil Recovery*: carbon dioxide is pumped into depleting oil fields as a recovery agent to increase oil production;
- *CO_2 reduction*: carbon dioxide is stored in the subsoil, using depleted oil or gas fields, saline aquifers or sandstone formations;
- *Enhanced Coal Bed Methane Recovery*: carbon dioxide is injected in suitable gas formations to enhance coal bed methane production;
- *Industrial purposes*: carbon dioxide is conveyed to greenhouses and used to boost plants' growth.

The first remarkable aspect which emerges from the previous table is that in North America carbon dioxide pipelines are mainly used for fossil fuels industry in order to increase oil fields productivity. On the contrary, in Europe, the higher ecological conscience focuses on the application of CCS technology for CO_2 storage in order to reduce the emissions in the atmosphere. If from an ethical point of view the European position seems more responsible, from a profitability point of view CO_2 transport and storage infrastructure does not have any additional revenue that can amortize the investments. In this situation, European or national financial supports are necessary to encourage the spread of CO_2 transport infrastructure.

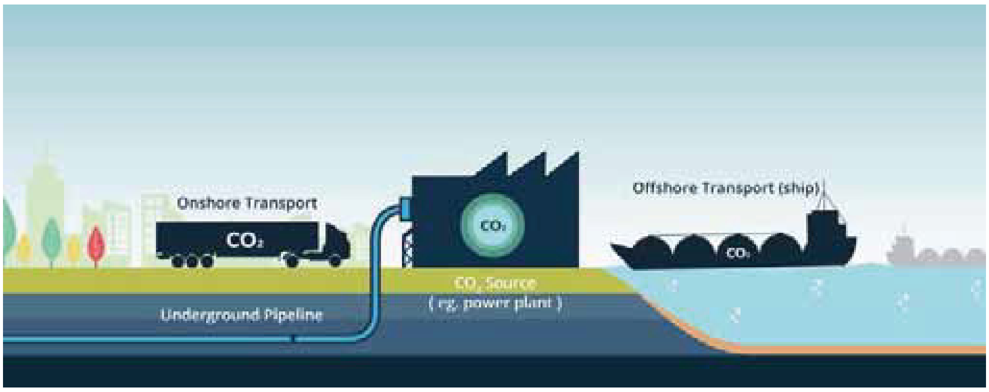

Fig. 171 CO_2 transport (source: co2degrees.com)

The framework could change if CO_2 could be re-used for other industrial uses in order to generate high value added revenues. Coupling carbon dioxide capture with algae biomass production, for example, could create additional gains thanks to the high value added of algae by-products, and this could contribute in spreading a necessary carbon abatement technology.

A beneficial environmental and economic factor which could positively affect on CO_2 recovery business plans should be to re-use oil or gas pipelines. In this case, a preliminary technical survey should be conducted on the existing pipeline in order to verify its compatibility with carbon dioxide transportation. Making the necessary modifications and implementations to an existing infrastructure could drastically reduce the cost and increase the economic feasibility of the entire operation. Some of the above-mentioned projects for CO_2 transportation in Europe are the result of a reconversion of ancient fossil fuels pipelines (OCAP, Lacq and Peterhead). In addition, the possibility of connecting OCAP and ROAD pipelines project is being studied in order to create a CO_2 hub in Rotterdam that can provide CO_2 to the agricultural production area in greenhouses a few kilometres away from Rotterdam (Ros et al., 2014).

Fig. 172 OCAP pipeline (source: Ros, M. et al., 2014)

Fig. 173 CO_2 network in Rotterdam through ROAD and OCAP connection (source: Ros, M. et al., 2014)

The potential for the recovering of oil infrastructure for carbon dioxide transport is vast and is attested by the large amount of academic papers and EU funded projects concerning carbon dioxide transport. According to Rabindran (2011), the success of the recovering operation depends on a risk assessment which has to consider the type of pipeline construction material, the wall thickness and CO_2 condition for transportation.
Carbon dioxide can exist in a gaseous, liquid or solid state, depending on temperature and pressure conditions, and its characteristics for transportation are completely different. Rabindran (2011) states that carbon dioxide transmission in long-distance pipelines is optimal when CO_2 reaches its supercritical phase, as the fluid has the density of a liquid and the viscosity and compressibility of a gas. The higher efficiency of this kind of status is due to the lower friction along pipelines per unit mass of CO_2. Impurities, in particular water particles, in carbon dioxide stream could result to be very detrimental, because they could start an internal corrosion process of pipelines.

The issue of the implementation of a continental CO_2 transport network is also of great interest for the European Union. .
The *CO2EUROPIPE*[6] project, for example, investigates the requirements for the implementation of a large-scale CO_2 infrastructure between 2020 and 2050, basing its assumptions on the expected CO_2 captured volumes during that period and on the identification of suitable underground storage sites. The research results in a series of maps of plausible CO_2 transport corridors in north-west and central Europe and in the statement of those necessary technologies, policies, regulations and organisational requirements for the development of this infrastructure.

A different scenario is presented by *COCATE*[7] project concerning the applicability of a large-scale CCS transportation infrastructure in order to collect flue gas from small carbon dioxide emitters, so widening the possible involved industrial actors.

The potential of a trans-regional CO_2 transportation infrastructure is described by *COMET*[8] project which looks at western Mediterranean region (Portugal, Spain and Morocco) as a case study where to implement CCS technology. At present the region deeply lies on a tight bond between fossil fuel energy and local

6 *CO2EUROPIPE (Towards a transport infrastructure for large- scale CCS in Europe) is a EU-funded project under the* FP7 - Energy - Specific Programme Cooperation: Energy (see www.co2europipe.eu)
7 *COCATE (Large-scale CCS transportation infrastructure in Europe) is a EU-funded project under the* FP7 - Energy - Specific Programme Cooperation: Energy (see www.zeroco2.no/projects/european-cocate-project)
8 *COMET (Integrated infrastructure for CO_2 transport and storage in the west Mediterranean) is a EU-funded project under the* FP7 - Energy - Specific Programme Cooperation: Energy (see http://comet.lneg.pt/)

energy operators and is characterised by very different economic developments and ecological conscience.

CO_2 storage (CCS) or re-use (CCU)

After transportation, carbon dioxide can be stored or used for some industrial purposes. In the first case, depleted underground fossil fuels deposits are suitable geological formations which can accommodate carbon dioxide in a liquid or supercritical phase thanks to their temperature and pressure. Other appropriate storage sites in the long term include deep saline formations and sandstone formations.

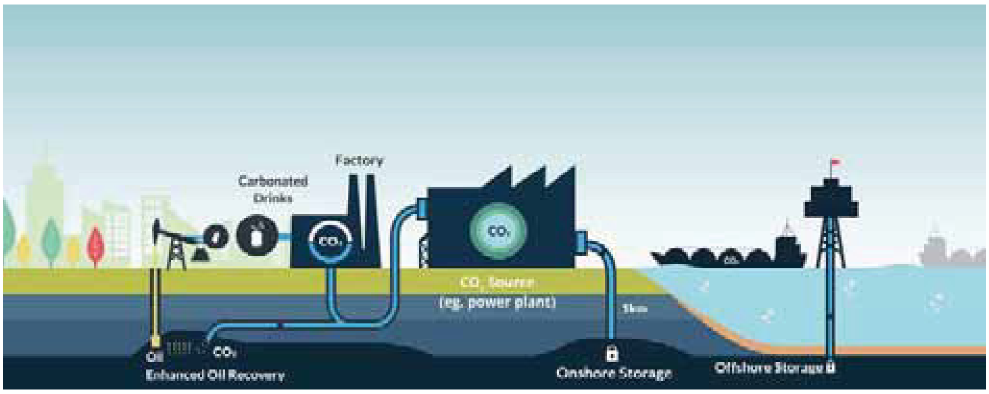

Fig. 174 CO_2 Use & Storage (source: co2degrees.com)

The *CO2SOLSTOCK*[9] EU funded project investigates the potential of a bio-mimetic processing of CO_2 sequestration using bacteria in order to induce a calcium carbonate precipitation. The high value added of this approach to CCS technology is dual: CO_2 could be stored in a solid and more stable state and it could fix either atmospheric CO_2 or organic carbon, saving energy and contributing in a massive CO_2 reduction.

As previously anticipated, carbon storage is not the only final scenario envisaged for CO_2 capture. Among the alternatives to underground storage, some EU funded projects present innovative solutions that can be developed on an industrial scale in the medium term, thus obtaining by-products from CO_2 processing. As already seen before, carbon dioxide could be combined with algae biorefineries to enhance the algal biomass growth. In this case, carbon dioxide is pumped into translucent photobioreactors tubes and then absorbed by micro-algae.

Different CO_2 re-use scenarios are investigated in *SCOT*[10] project, which looks at carbon dioxide as a very flexible source of carbon and proposes to tranform it into high value added products such as chemical feedstocks, synthetic fuels

9 *CO2SOLSTOCK (Biobased geological CO_2 storage) is a EU-funded project under the* FP7 - Future emerging technologies (see www.co2solstock.eu)

10 *SCOT (Smart CO Transformation) is a EU-funded project under the* FP7 - Regions (see www.scotproject.eu)

or building materials. The upcycling of carbon dioxide and the implementation of a profitable CO_2 value chain is an aspect of strategic importance to foster a strategic industrial symbiosis between CO_2 producers and consumers in view of a circular economy.

hydrogen technology

The implementation of the *hydrogen technology* is considered a necessary step towards a low-carbon economy to foster a massive renewable energy transition (Rifkin, 2011). One of renewable energies' critical problems concerns their intermittent energy production, which, being unstable, it has to be used on time and on site or re-entered in the national electrical grid. At the moment, it results to be difficult to stock peaks of seasonal electric production in order to supply for the surplus in energy demand. This is the reason way hydrogen technology could be a very attractive solution to store renewable energies: through electrolysis, electricity can be transformed in oxygen and hydrogen.

Hydrogen can be obtained from several sources, and electricity is only one of them. In fact, at the moment, the most advantageous source of hydrogen is fossil fuel downstream process. *Steam reforming* is the most widespread technique which allows to produce hydrogen from natural gas, but it results to be the by-product of *cracking petrochemical processes*, making its ecological balance negative.
Water represents another interesting source of hydrogen production. Through hydrolysis, it can produce high value added by-products useful for other industrial domains, such as glycerol for cosmetics and polymers industry, acetate from bioethanol for food industry and lactic acid for biodegradable plastics' production.

Even *algae cultivations* in closed photobioreactors can be providers for hydrogen production. In fact, if algae are deprived of sulphur during their growth, they stop producing oxygen and they synthetize hydrogen as the result of the photosynthesis process. Bio-hydrogen production from micro-algae photobioreactors could be even more sustainable if combined with Carbon Capture and Use (CCU) technology.

Hydrogen distribution is another important subject that is particularly studied in order to find innovative and feasible solutions. The transition towards a low-carbon economy will require the development of a new specific hydrogen infrastructure and its implementation will take some decades. In fact, at the moment, only few kilometres of hydrogen pipelines has been developed in Europe (UK, Netherlands, Germany) to connect refineries to petrochemical sites or to other industrial districts.

According to Corbo et al. (2011), two are the scenarios which could foster a wide H_2 infrastructure network:

- a centralized hydrogen production and distribution, similar to the existing energy cycle strategies;
- a territorial distributed hydrogen production through small-medium scale filling stations.

hydrogen distribution and storage in a centralized production scenario

If we consider the first scenario, the centralization of hydrogen production would need to implement infrastructure and means of transport: the hydrogen produced by steam reforming processes in industrial plants, for example, would require the implementation of a pipeline network for the transportation of huge quantities for long distances or it would be transported on public roads by high capacity trailers under high pressure.

It is interesting to note that the EU-funded project *DELIVERHY*[11] investigates how road circulation's regulations, codes and standards could change in order to admit the transportation of hydrogen by trailers with a higher pression than 65Mpa.

Hydrogen storage raises other issues concerning its unstability and explosivity. Researchers of *FLYHY*[12] project are investigating on cost-effective technical solutions in order to transform hydrogen in a liquid, gaseous or even solid state and store it in safer and more stable conditions.

The *IDEALHY*[13] research focuses on the efficiency of a hydrogen liquefaction process if compared to a gasesous compression one. According to the results of this EU-funded project, liquid hydrogen has a higher energy density than compressed hydrogen and can be transported more efficiently.

Once hydrogen is transformed in a more stable state, it has to be stored somewhere. Some research investigates the possibility and feasibility to stock large hydrogen quantities in a compressed gaseous state in depleted oil and gas fields or in salt cavernes (for example Mignard et al., 2016, Basniev et al., 2010 and EU-funded project *HYUNDER*[14]).

hydrogen distribution and storage in a distributed production scenario

Taking into consideration the second scenario, a small-medium distributed hydrogen production (based on either small reforming plants or on small-size electrolyzers) could strongly reduce the impact of transport costs. In fact, small-medium hydrogen stations could lie on the existing gas pipelines network, which

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11 *DELIVERHY (Optimisation of Transport Solutions for Compressed Hydrogen) is a EU-funded project under the* FP7 - JTI (see www.deliverhy.eu)

12 *FLYHY (Storing hydrogen in solid form for mobile application) is a EU-funded project under the* FP7 - NMP

13 *IDEALHY (Integrated Design for Efficient Advanced Liquefaction of Hydrogen) is a EU-funded project under the* FP7 - JTI (see www.idealhy.eu)

14 *HYUNDER (Assessment of the potential, the actors and relevant business cases for large scale and seasonal storage of renewable electricity by hydrogen underground storage in Europe) is a EU-funded project under the* FP7 - JTI (see www.hyunder.eu)

could be used to distribute and store smaller, but more distributed, quantities of hydrogen. The *NATURALHY*[15] project, funded by the European Commission under the 6th Framework Programme, focused on the possibility to transfer hydrogen through the existing gas pipelines network. The results of the research confirm that this scenario is feasible and a hydrogen quota could be mixed with the natural gas that normally flows in the national grid of gas pipelines.

Due to high hydrogen energy density, no current existing materials are capable of storing enough hydrogen. Thus, a very interesting and promising research branch is related to novel nanocomposite materials (combining metal hydrides) which could be suitable for hydrogen storage (for example the EU-funded projects *NANOHY*[16], *ATLAS-H2*[17]), in order to improve the carbon-free automotive industry which is closely linked to innovative solutions for hydrogen fuel cells. According to Rifkin's five pillars for the energetic transition towards the third industrial revolution (2011), even fuel cell vehicles, once plugged to a smart, interactive power grid, could buy or sell, exchange or store electricity under hydrogen form, thus giving a significant boost to a distributed production and storage energy model.

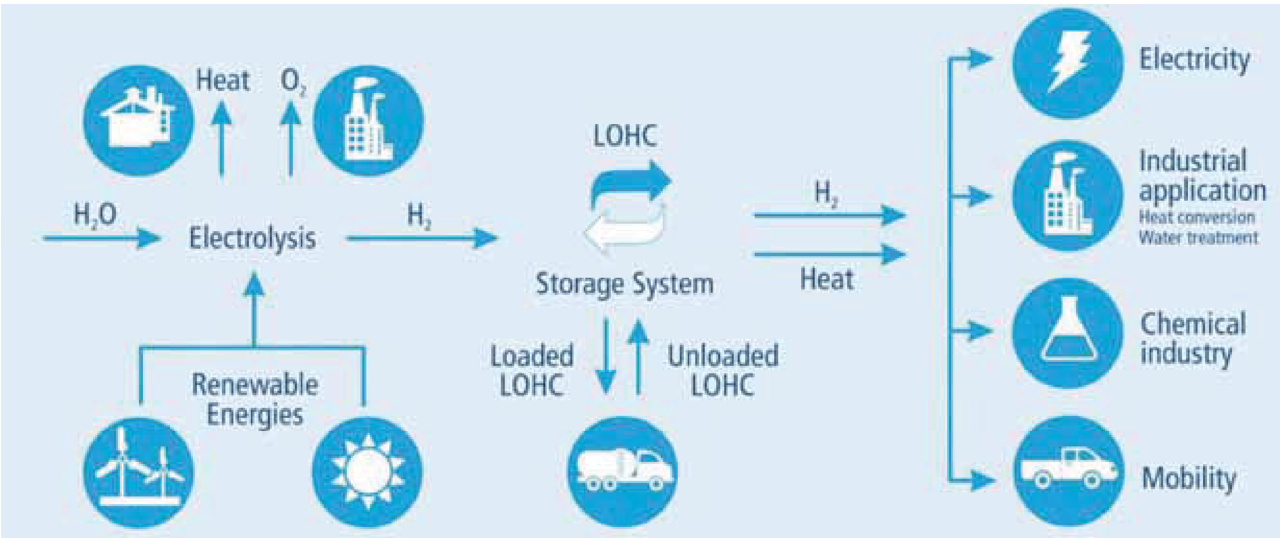


Fig. 175 Hydrogen production, transport, storage and use network (source: Hydrogenious)

15 *NATURALHY (Preparing for the hydrogen economy by using the existing natural gas system as a catalyst) is a EU-funded project under the* FP6 -SUSTDEV - New technologies for energy carriers - Hydrogen

16 *NANOHY (Novel nanocomposites for hydrogen storage applications) is a EU-funded project under the* FP7 - ENERGY

17 *ATLAS-H2 (Advanced Metal Hydride Tanks for Integrated Hydrogen Applications) is a EU-funded project under the* FP7 - PEOPLE

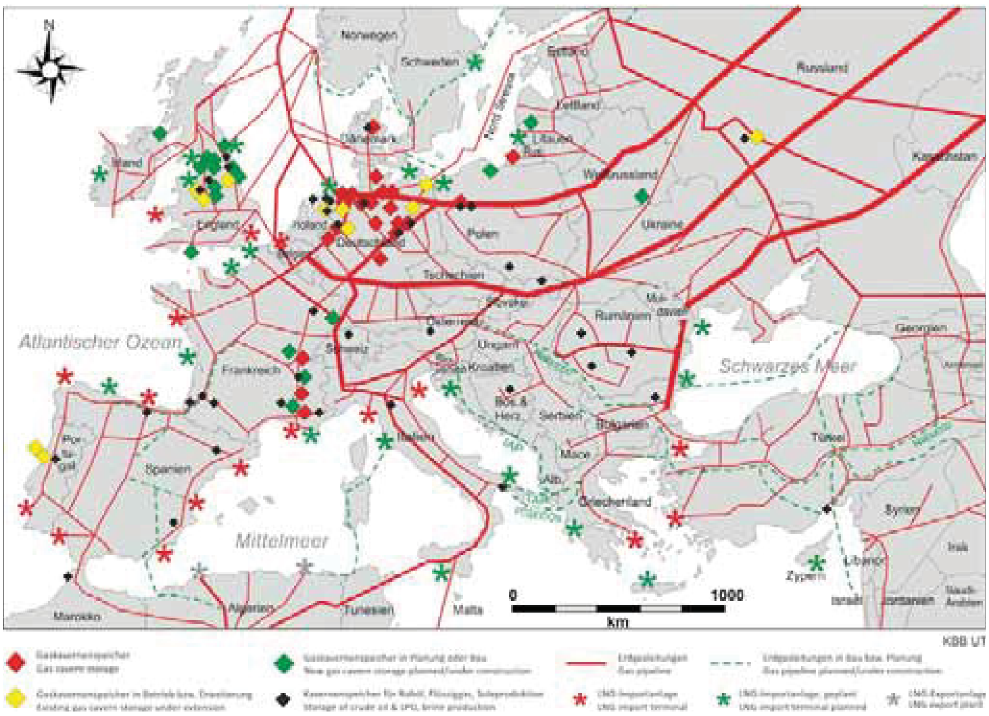


Fig. 176 Hydrogen netwotk implementation: main European gas pipelines and cavern storage (source: KBB Under Technologies)

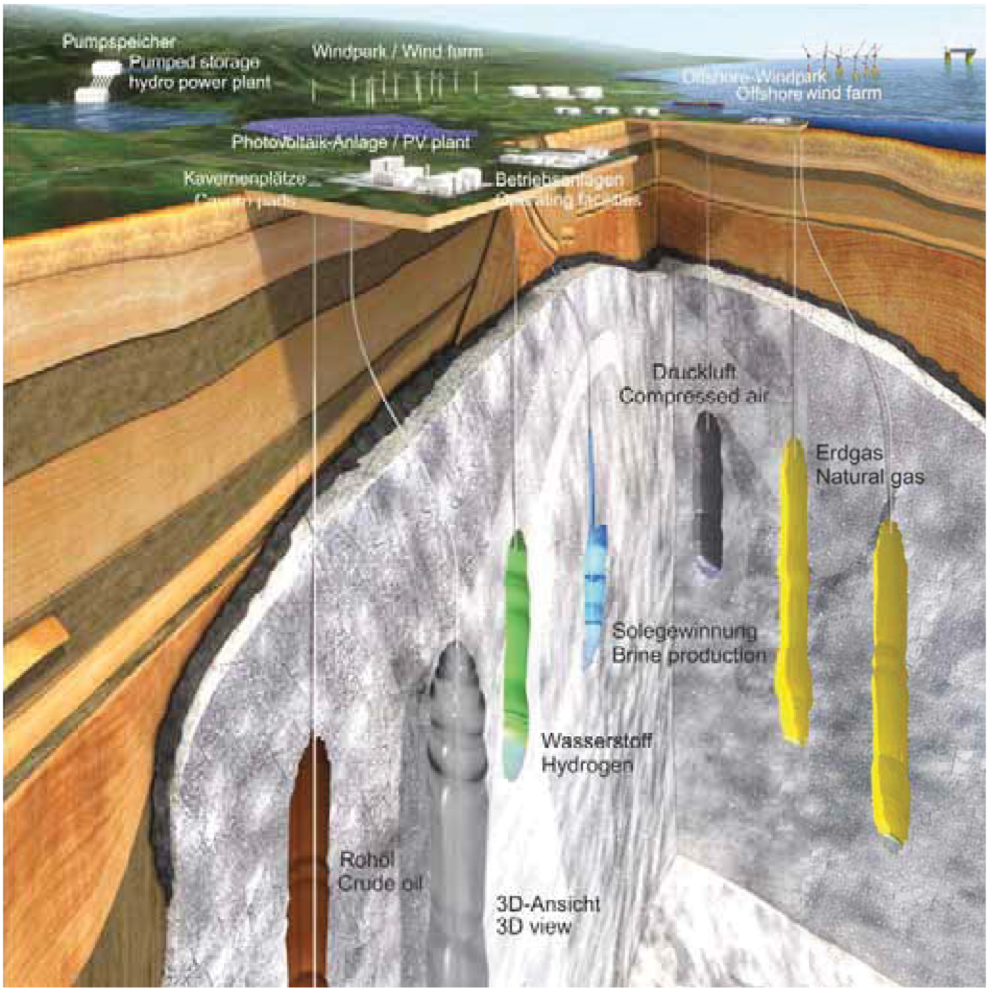
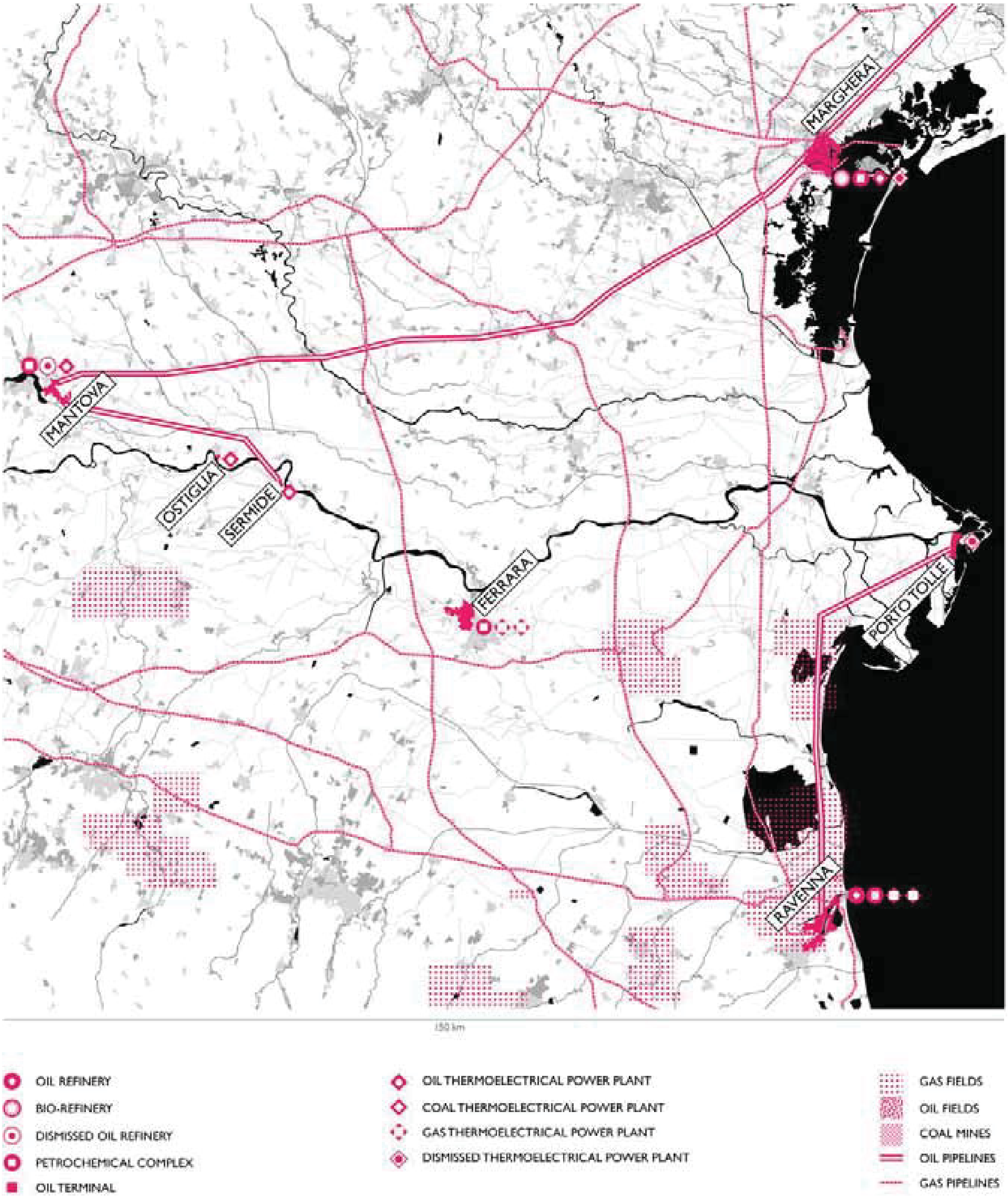


Fig. 177 Hydrogen underground storage (source: KBB Under Technologies)

PART IV



sources: **Geographical metadata**
- Corine Land Cover 2012 metadata: www.eea.europa.eu
- DIVA-GIS metadata: www.diva-gis.org

Fossil fuels metadata and information
- Italian Economic Development Ministry metadata: http://unmig.mise.gov.it/unmig/titoli/elenco.asp?tipo=ICT
- Typology and general information about refineries and power plants: www.globalenergyobservatory.org;
- ENI oil and gas pipelines: ENI factbook 2014: http://www.eni-italy.info/ENI_Web/World-Oil-Refineries-List., https://www.eni.com/it_IT/innovazione/piattaforme-tecnologiche/green-refinery.page;
- ALMAPETROLI infrastructures' information: http://www.almapetroli.com/index.php/it/home-4/;
- IES infrastructures' information: https://molgroupitaly.it/it/mol-group-italy/mol-group-italy-chi-siamo/ies-italiana-energia-e-servizi;
- ENEL power plants' information: https://www.enel.it/it/futur-e.html;
- A2A power plants' information: http://www.a2a.eu

Fig. 178 North-eastern Po Valley oil mesh (source: elaborated by the author)

Energy landscapes

A territorial case study: the north-eastern Po Valley oil mesh

fossil fuel landscapes

In order to try to make practical our theoretical assumptions, we need a concrete case study on which focusing our cartographical analysis. Among the eight Adrion oil meshes previously considered in the taxonomic analysis, we think that the north-eastern Po Valley oil mesh could offer us several cues due to its complexity and diversified oil infrastructure type.
Thus, let us take into consideration the 150x150 km territorial portion and focus on the many oil industry sites on the territory and on their interconnections.
We would like to resume the taxonomic cartographical assessment in order to quickly describe the distribution of the centralized energy production system of oil industry in the north-eastern Po valley as follows:

Porto Marghera industrial harbour (Venice)

• in the northern part, we can find one of the most important and the most ancient Italian refinery (belonging to Eni group) which has been operational since 1926. In 2014 it has been transformed in a bio-refinery for the production of biodiesel from imported palm oil;

• in the central part, corresponding to the second phase of the industrial Porto Marghera harbour development and implemented after the World War II, a huge petrochemical plant (currently owned by Versalis, Eni group) lies and since the 1950s has been using light petroleum distillation derivatives in order to produce compounds and raw material for the production of a wide range of chemical products, from detergents to fertilizers, elastomers, synthetic fibres, plastics, etc.;

• in the same Porto Marghera industrial harbour area, the thermal power plant "Giuseppe Volpi", fueled by coal and oil, operated since 1922 until 2012;
• in the southern part, in the locality of Fusina, we can find another thermal power plant which is still operational, that is to say the "Andrea Palladio" one (owned by Enel) and powered by coal, dense oil and methane;
• in proximity, the "Integrated Project Fusina" stands for the evolution of the existing sewage treatment plant for Porto Marghera industrial waste waters into a "multifunctional platform", which, after an initial chemical-physical treatment, continues with a phyto-purification system by passing industrial waste waters through some wetland areas (Cassa di Colmata) extending over 100 ha, of which 30 ha are used for recreational and educational purposes.

Polesine Camerini thermal power plant (Porto Tolle, Rovigo)
• in the very middle of the Po delta, very close to the very fragile ecosystem of the Veneto Natural Park of Po delta and in one of the most scarcely inhabited Italian municipalities (Porto Tolle, 39 inhabitants per hectare), Enel settled one of the biggest oil-powered thermal power plant in Europe (2'640 MW). The power plant started operating in the 1980s, energy production stopped in 2009 and the site was definetely shut down in 2015.

Ravenna industrial harbour
• Ravenna harbour houses a still operating refinery (AlmaPetroli) and a petrochemical complex (belonging to Versalis), not far from Piallassa Baiona wetlands and Comacchio valleys natural protected areas;
• an oil storage area lying in the Ravenna harbour fed Polesine Camerini power plant by an underground oil pipeline (90 km) crossing the Natural Park of the Po Delta.

Ferrara petrochemical site
• in the north-western periphery of Ferrara (whose historical center is a UNESCO World Heritage Site) a huge petrochemical site, which dates back to the 1930s, transforms refined oil and gases in oil by-products (plastic, etc.). It lies along the Boicelli canal, an artificial watercourse realized during the 1930s in order to link the Po river to its ancient branch (Po di Volano) and better connect the industrial area with a water accessibility.

Mantua oil sites
• a petrochemical complex (owned by Versalis) and a refinery (IES) lie along

Fig. 179 Porto Marghera industrial harbour (source: Bing Maps)

Fig. 180 Polesine Camerini thermal power plant in Porto Tolle municipality (source: Bing Maps)

Mincio river, in front of Mantua historical city center and in continuity with Regional Natural Reserve Vallazza. The refinery is completely dismissed and actually used only as storage for Porto Marghera refinery's by-products. In fact, a long underground oil pipeline (120 km) connects Mantua oil refinery with Porto Marghera one;
• the area is also connected with the Po Delta and the Adriatic sea through the Fissero-Tartaro-Canalbianco navigable waterway.

Sermide thermal power plant (Mantua)
• in the locality of Sermide, 40 km far from Mantua, a combined natural gas and oil thermal power plant (1'154 MW) has been producing electric energy since 1985. An underground oil pipeline directly connects Sermide power plant to the refinery in Mantua. The oil-powered turbines stopped working in 2004.

Ostiglia thermal power plant (Mantua)
• not far from Sermide and Mantua, another still operational thermal power plant (1'140 MW) lies along the Po river, in the village of Ostiglia. Previously fueled with a mix of oil and natural gas, since 2003 the power plant has been partially transformed into a combined gas cycle with three CCGT modules (combined cycle gas turbines).

Fig. 181 Ravenna industrial harbour (source: Bing Maps)

Fig. 182 Ferrara petrochemical plant (source: Bing Maps)

Fig. 183 Mantua petrochemical plant and refinery (source: Bing Maps)

Fig. 184 Sermide thermal power plant (source: Bing Maps)

Fig. 185 Ostiglia thermal power plant (source: Bing Maps)

regional district

Since the north-eastern Po Valley oil mesh spans across vast and different territories, overtaking with indifference administrative boundaries and socio-economic differences, we propose to use some GIS tools intersecting statistical and geographical data in order to understand the internal territorial trends.

The objective of this analysis is to translate into territorial indicators and cartographies the notion of "regional district" ("comprensorio regionale" in the original language) proposed by the Italian urban planner Giuseppe Samonà in the 1960s. As asserted by Infussi (1992, p.226), Samona's experience of regional districts aims to define a planning dimension that is not more related to administrative criteria, but rather identifies itself as a project entity which responds to "maximum economic efficiency and convergence of activities".

Regional districts are defined by similar socio-economic trends and share local development strategies that must respond to comparable contexts and problems.

The "Regional District Plan for Polesine Municipalities" (Samonà, 1961, annex 2) is a document of extreme importance to understand the historical and cultural context in which Samonà's urbanism vision emerged in complete rupture with modernist planning tendencies. According to him, the tendency of the Modernist movement to reduce to universalizing interpretations the specific territorial situations, made up of physical, social and anthropological dimensions, would have led to a loss of local historical and cultural values (Infussi, 1992). Thus, the main task of the planning activity is to guarantee the permanence of these characterizing elements through norms that interpret their differences and specific development needs, both within the peculiar situation and in relation to wider territorial contexts.

In the specific case of Polesine, that is to say those territories that extend in the southern part of the province of Rovigo along the Po river up to the delta, Samonà identifies in the need to solve the natural disasters linked to frequent floods that triggering factor to undertake a territorial planning process.

The clear definition of the problem becomes a driving force in proposing a far-reaching planning approach that also involves agricultural and industrial development, as well as infrastructure modernization, and does not want to stop at a mere planning of hydraulic engineering works. The "Regional District Plan for Polesine municipalities" becomes a tool to reposition the region within national equilibriums and focus on the need for an infrastructural and accessibility enhancement to the area, thus defining new forms of economic and social development within the identitary image of the "urbanized countryside".

In the light of Samona's lesson, let's see now what indicators can be useful in identifying those local characters and similar socio-economic trends on which to base the proposal for a regional district where the conversion of oil infrastructure could become the driving force for a renewed local development.

Mobility indicator

It is noteworthy that the Adriatic coastal arc from Ravenna to Porto Marghera is not reached by any mobility infrastructure of national importance. The consequence is a vehicular congestion along the "SS 309 Romea", the only primary road which crosses from north to south the Adriatic coastal arc and which crosses the fragile protected areas of the Po Delta valley.
The railway infrastructure is also lacking in the Po Delta area and only the extremities of the Adriatic coastal arc, Chioggia and Ravenna, as well as Adria, are connected to the regional and national railway system.

Environmental indicator

All the downstream sites in the area are intersected by the Natura 2000 ecological network along two main axes, one north-south running parallel to the Adriatic coast and the other east-west along the banks of the Po river. The continuity between the protected areas of the Venetian Lagoon, the Po Delta Natural Park, the Comacchio valleys, the wetlands around Ravenna, the salt pans of Cervia and the banks of the Po represents the main ecological backbone of the area.

Social indicators

As regards "urban density variation" in a time span of ten years (2004-2014), it seems clear that a process of depopulation is taking place in the municipalities that lie along the two ecological axes of the area and that are more deprived of mobility infrastructure connections, with a peak that is reached right in the municipality of Porto Tolle. The only exceptions that register a slight demographic increase are located in correspondence with coastal municipalities with a tourist infrastructure linked to balneation, such as the municipalities of Rosolina and the lidos of Ferrara between the Po delta and Ravenna.
The cartography shows that the municipalities of Polesine and also the coastal municipalities from Chioggia to Ravenna have a percentage of population over 65 which on average exceeds 25% and in some cases exceeds 30%.
As far as the presence of foreign people is concerned, it can be observed that the coastal municipalities south of Porto Marghera up to Comacchio register very low rates (less than 5%), as well as the inner municipalities of Polesine along the river Po, both on the Veneto and Emilia-Romagna sides. This indicator also describes the low economic and labour attractiveness of this region.

Commuting cartography offers us a double reading of the phenomenon:
• peripheral municipalities around major urban centres are those which record the highest commuting rates, as they are usually attracted by the job opportunities of nearby main cities;
• those territories which lack of mobility infrastructures, such as those of the Polesine and the Po Delta, record lower commuting rates, around 50% in average, reaching peaks of 55% in the most extreme eastern municipality of Porto Tolle. The scarce transport infrastructure network and the absolute lack of public transport services make necessary to use massive amounts of individual motorized transport for long distances, thus creating traffic congestion on the few available infrastructures and having a very high environmental impact.

Economic indicators

The entire Polesine area and the coastal strip, from Porto Marghera to Ravenna, have a very low entrepreneurial density, with an average of less than 20 units per square kilometre.
From a tourist point of view, average overnight stays is the Polesine area is approximately between 1-3 nights, but there are some municipalities that stand out from this figure thanks to their summer offer related to family balneal tourism, such as the lidos of Ferrara and Rosolina. Even the municipality of Porto Tolle, with its slow, ecological and nautical tourist offer, attracts a niche of tourists accommodating in the area up to an average of 10 nights.

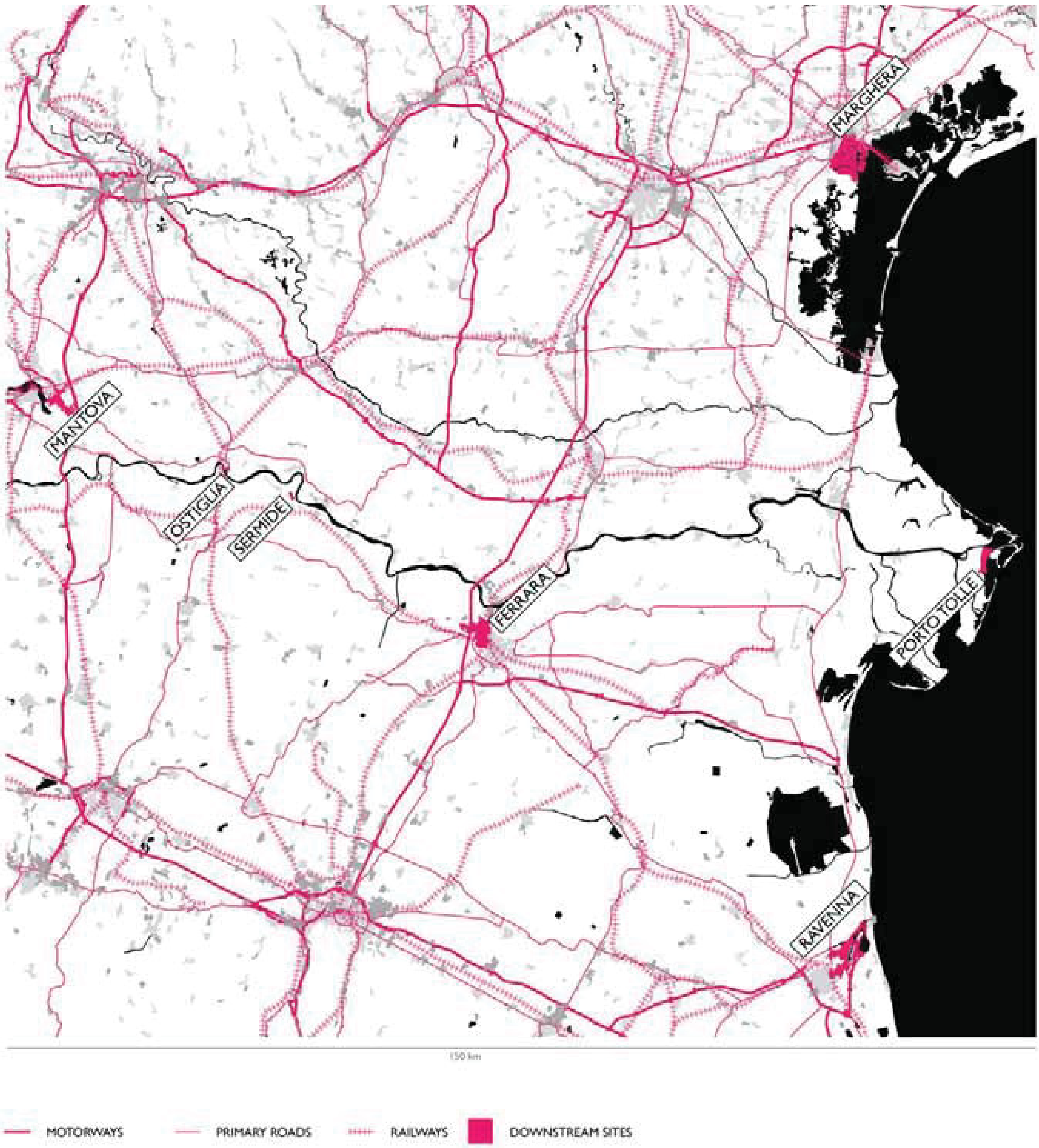


Fig. 186 Mobility indicator (source: Corine Land Cover, Diva-GIS; elaborated by the author)

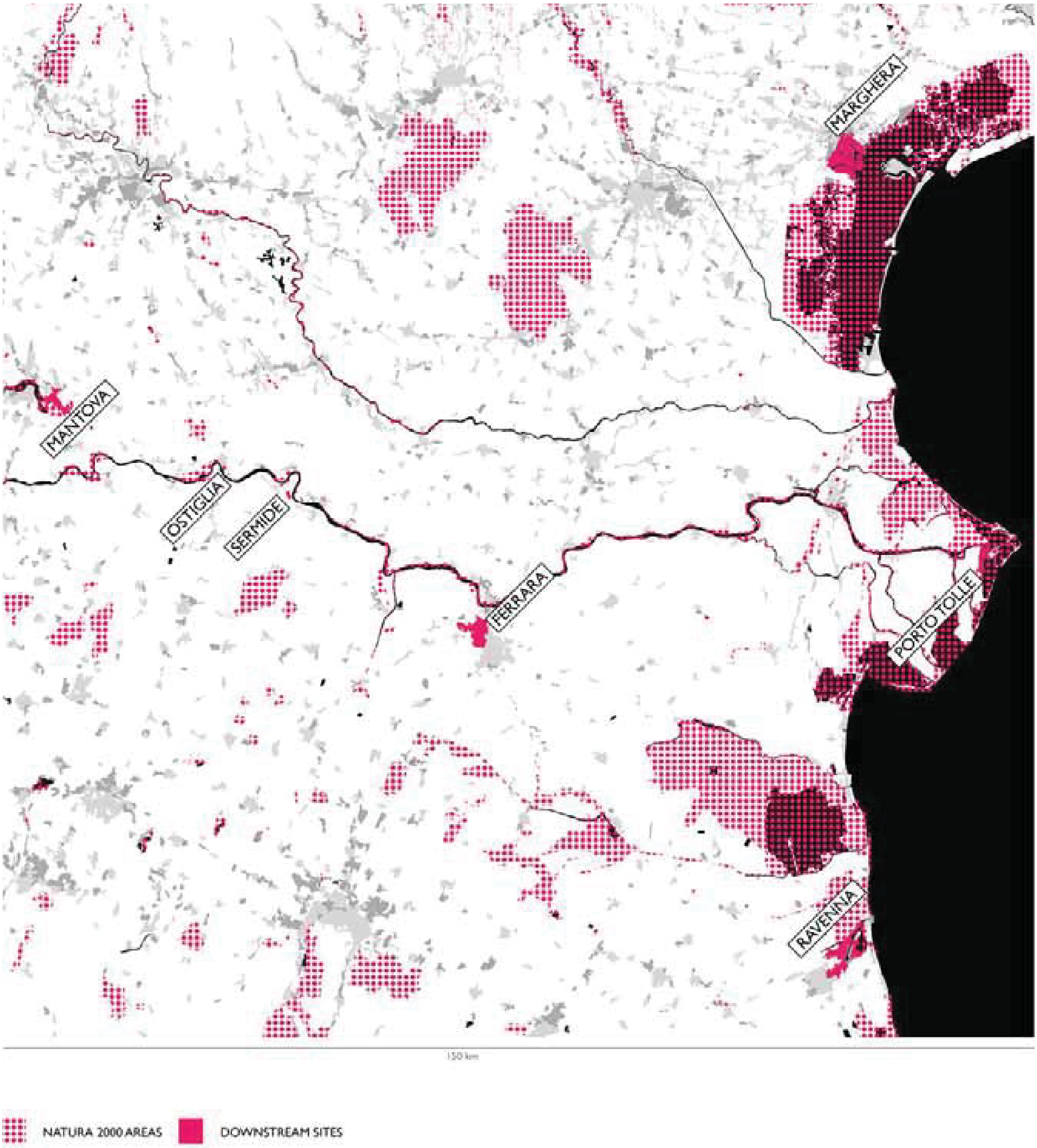


Fig. 187 Environmental indicator (source: Corine Land Cover, Diva-GIS; elaborated by the author)

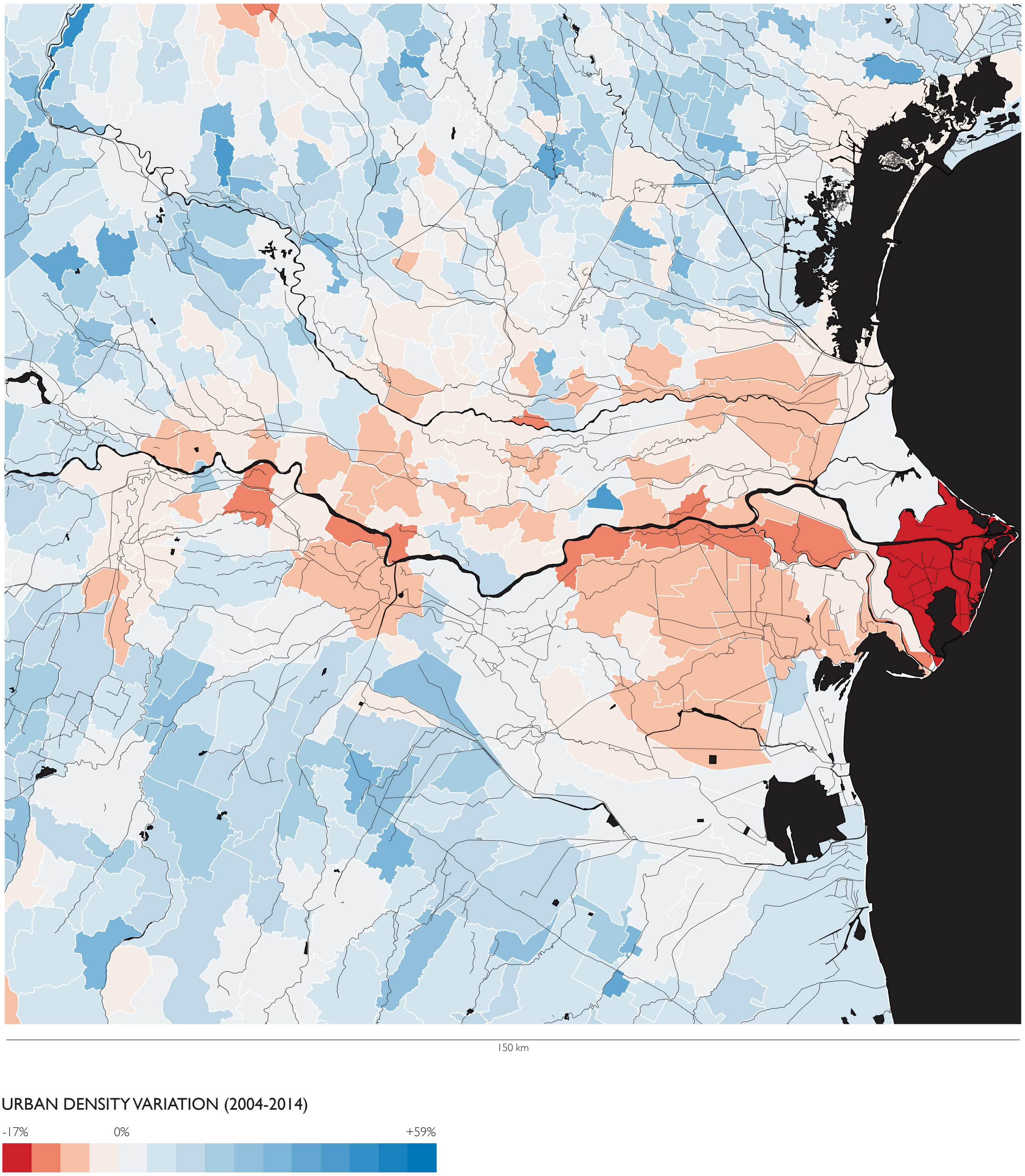


Fig. 188 Social indicator: Urban density variation (source: Corine Land Cover, Diva-GIS, ISTAT, annex 3; elaborated by the author)

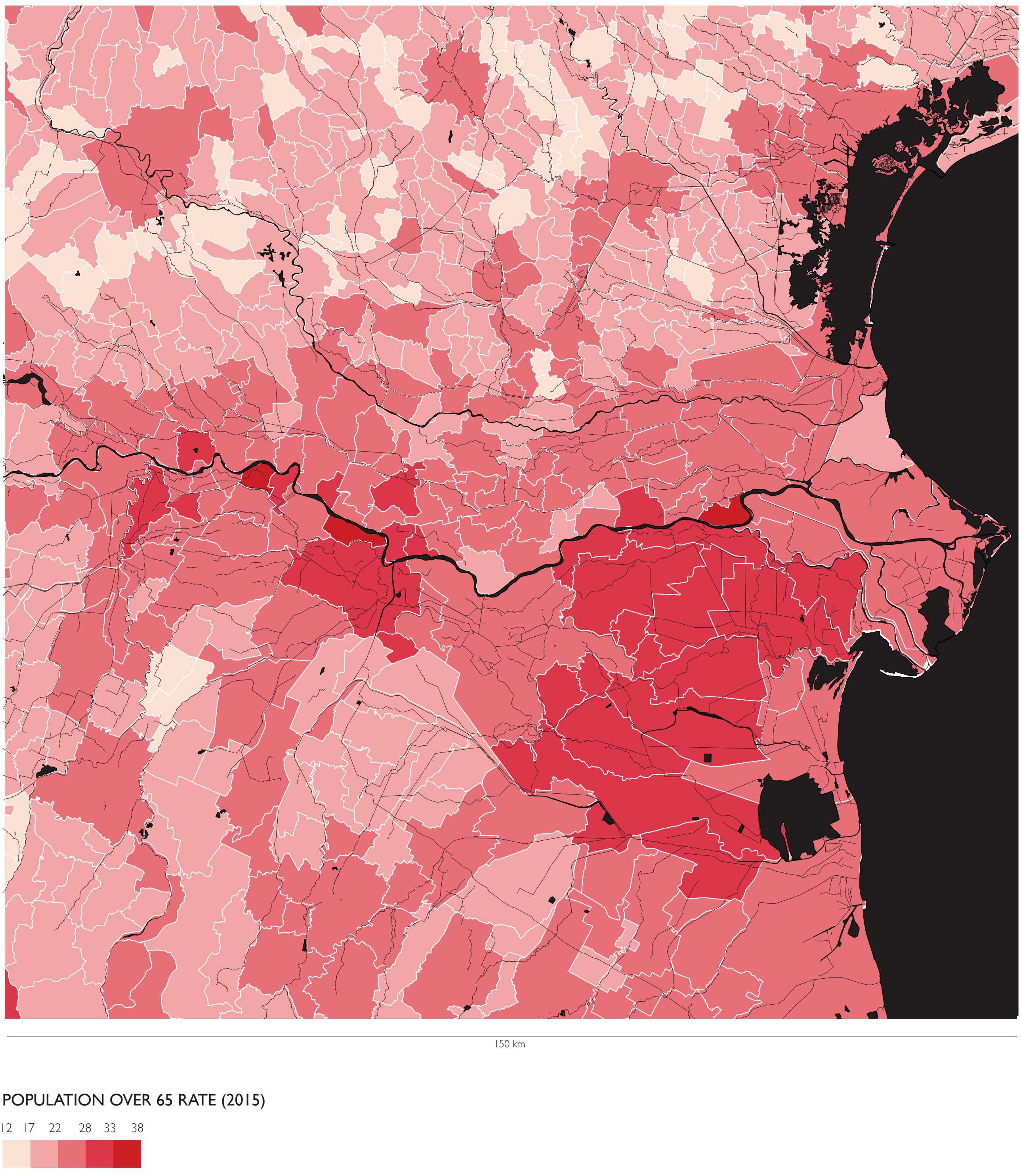
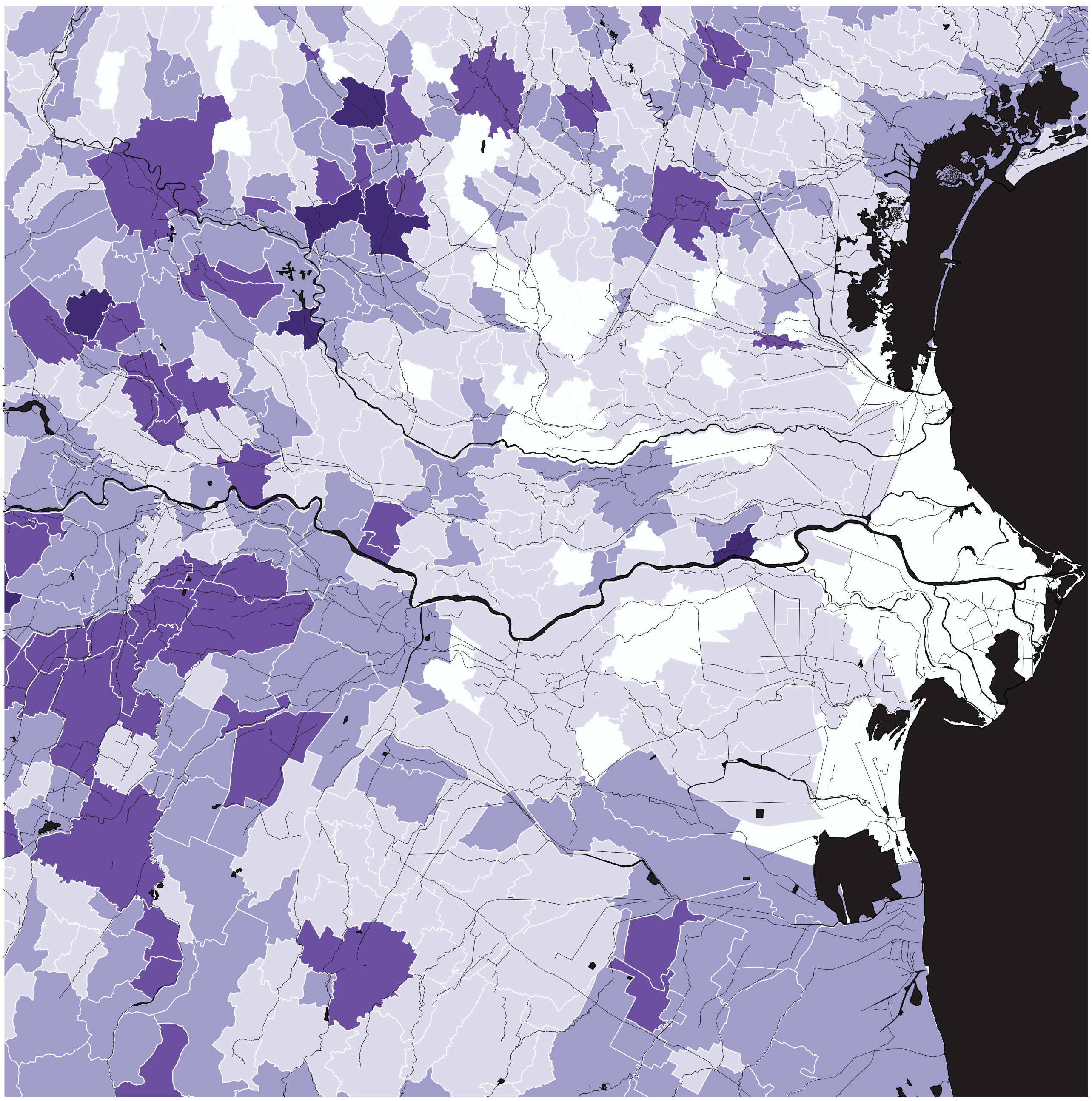


Fig. 189 Social indicator: Population over 65 rate (source: Corine Land Cover, Diva-GIS, ISTAT, annex 3; elaborated by the author)

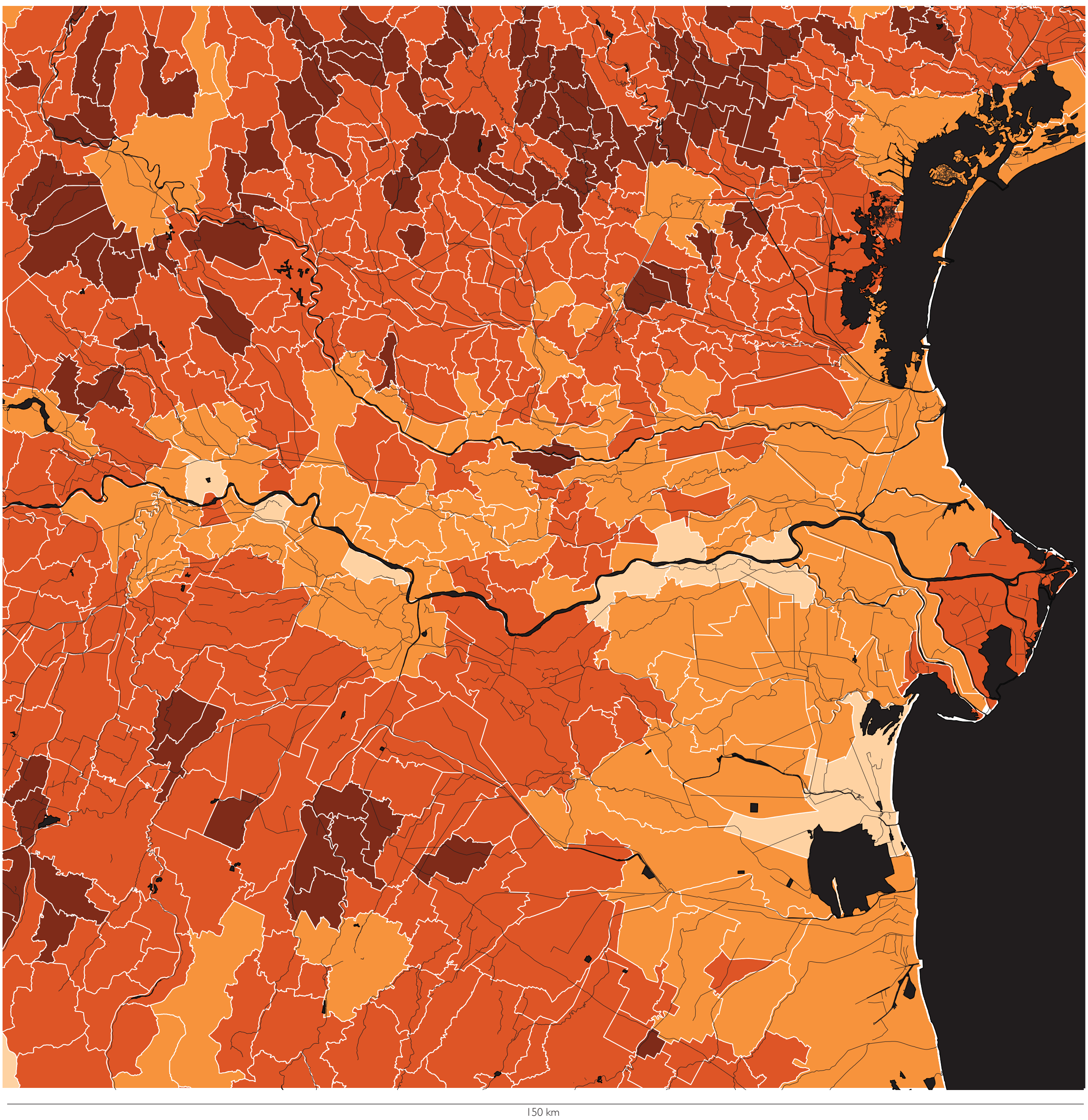


150 km

FOREIGN PEOPLE RATE (2015)

1 5 10 14 19 23

Fig. 190 Social indicator: Foreign people rate (source: Corine Land Cover, Diva-GIS, ISTAT, annex 3; elaborated by the author)



COMMUTING RATE (2011)

31 38 44 50 57 63

Fig. 191 Social indicator: Commuting rate (source: Corine Land Cover, Diva-GIS, ISTAT, annex 3; elaborated by the author)