From a Vision to a Necessity – from a Necessity to a Vision. Thermal Waste Processing Plants - Case Study: Italy

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Abstract. While searching for the answer to the manner of addressing the problem of waste that is produced in cities, we are on the one hand faced with the necessity of solving it in a fast and effective way, while on the other with searching for effective plans of long-term solutions in this regard. Any prospective answer to the question about the management of municipal waste most often applies not to the processing of waste itself, but efforts being made so that the amount of waste that cannot be subjected to so-called recycling will be as low as possible. The term "cradle to cradle", which is a current where a used product becomes a material for the production of a new one, is one of the main ideas which are at the helm of modern, pro-environmental visions of broadly understood resource management. However, pro-environmental, futuristic ideas regarding waste management are faced with the necessity of being confronted with the current state. One of the most effective means that provide an answer to actual, modern needs is the construction of thermal waste processing plants. The goal of this article is to determine the answer to the question whether - and if so, then in what manner - a visionary approach in terms of environmentally friendly cities has any effect on modern efforts and the solving of problems associated with waste management in cities. Do modern efforts regarding the actual protection of the environment follow far-reaching visions, or are they only an immediate answer to urgent problems? Examples of built projects of thermal waste processing plants, which were built not as a part of far-reaching plans, but as the result of taking quick and urgent "here and now" action due to threats to human life and a high degree of pollution in a city, have been analysed in the article. The analyses that have been carried out will make it possible to formulate conclusions which will be able to serve as reference material during research on both theoretical models of pro-environmental cities and on modern efforts regarding municipal waste management.

1. Introduction
Due to the manner of the management of the resources that are at our disposal, the twentieth century can be described, from the perspective of the functioning energy economy, as an age of coal. The depletion of its deposits, as well as of other natural resources, but primarily the increasing level of the pollution of the environment, have led to a situation in which we are searching for new solutions - on the global and local scale - both in terms of broadly understood environmental protection, as well as the satisfying of our energy needs in an environmentally friendly manner, in accordance with the
principle of sustainable development. One of the key elements of environmental protection is - as much as it is possible - the reclamation of already used resources. Poland, as one of the EU member states, is obligated to adapt its policies to the general EU principles in terms of legal matters (in detail) as well as concerning the overall idea of ensuring integrity and beneficial cooperation among the member states (in general). The EU member states are departing from the idea of the Linear Economy in favour of a Circular Economy in their pro-environmental assumptions. One of the essential topics in this field is, undeniably, the protection of the environment, supported by various pro-environmental efforts. In this topic, it is key to pursue the answer to questions concerning the manner of obtaining resources, and then the management of municipal and other types of waste, in addition to the treatment of wastewater. These are efforts that directly affect the shaping of contemporary urban and suburban space due to the construction of pro-environmental structures, in this case - thermal waste treatment plants, popularly called eco-incineration plants, as well as wastewater treatment plants. Their role is essential both in terms of urban engineering, as well as planning, urban design and architecture.

This study is being published as a part of a cycle concerning structures with new pro-environmental functions as innovative elements of urban and suburban structures. The study focuses on two groups of structures: thermal waste processing plants and wastewater treatment plants. The matters under analysis had been divided into four thematic groups and systematised using a matrix structure (cf. B. Podhalański, 2017 [1]), according to table 1.

| Group 1 | Group 2 | Group 3 | Group 4 |
|---------|---------|---------|---------|
| Social  | Architecture | Locations/Accessibility | Urban Relations | Technical Issues |
| Thermal Waste Processing Plants | S/TWPP | A/TWPP | L/TWPP | U/TWPP | T/TWPP |
| Wastewater Treatment Plant | S/WTP | A/WTP | L/WTP | U/WTP | T/WTP |

Studies focusing on thermal waste processing plants in terms of social problems (group 1 - S/TWPP - "Social reception of thermal waste processing system structures"), architectural issues (group 2 - A/TWPP - "The beauty of eco-technology - thermal waste processing plants, as structures that increase the attractiveness of city spaces"), as well as problems from group 3, divided into problems concerning accessibility and the placement of structures (L/TWPP - "Thermal waste processing system structures. Questions of location and accessibility - Polish experiences"), as well as the subject of spatial relations (U/TWPP - "On the cusp of spatial challenges - the thermal waste processing plant as an element of urban space") were published as a part of the author's research. This article expands the abovementioned cycle by including an interesting example of field research in Italy, presented against the backdrop of the vision of environmentally friendly urban development and in reference to the necessity of building thermal waste processing plants.

2. Pro-environmental visions of the development of cities

The beginning of the twenty-first century and the possibilities that have appeared along with the development of contemporary new technologies provide a foundation for the shaping of new visions of the development of cities. Simultaneously, the depletion of natural resources, as well as the indirect and direct threat to health caused by human activity, creates a new spectrum of references and forces the necessity of pursuing new paths of development for cities, as well as a type of economy that can meet the postulates of the concept of sustainable development. From the contemporary use of energy
from renewable sources, through zero-emission, intelligent houses, new construction materials or pro-environmental solutions in everyday human life, to visions of commercial or residential structures that also absorb and then use smog in their technology, all the way to conceptual ideas of completely self-sufficient cities, these are only some of the elements of those new visions.

Ideas of a pro-environmental character can be divided into two types: focused efforts and comprehensive efforts. The prior are most often projects that refer to technological, ecological, economic or social solutions. Their common characteristic is that implementing such actions in urban structures is usually focused on a small area. The vast majority of the focused implementation of such ideas into various urban structures is undeniably positive, however there is often a lack of a broader perspective for a given possible project in the context of an entire city. These are ideas that can be implemented both in existing urban structures or they can be used in futuristic visions of cities built from the ground up (as constituent elements of a larger vision). In reference to the development of a city, we can discuss not only the introduction of individual pro-environmental solutions into existing cities, but also holistic, far-reaching visions concerning how a future city should look like - a zero-emission city, built from the ground up, a city that, as it functions, will not be consuming natural resources, but will beneficially affect the natural environment thanks to its solutions. Examples of such comprehensive solutions are often futuristic and far-reaching visions, but they also include currently applied concepts [2].

How and in what manner can such pro-environmental visions be referred to currently implemented urban solutions? Are they becoming an answer to the urgent problems of environmental protection either fragmentarily or holistically? Without a doubt, from among the plans and efforts mentioned above, the quickest to be introduced are public initiatives that are meant to be an answer to actually emerging threats: e.g. pro-social efforts referring to the matter of air pollution or the improvement of urban space on a small scale. However, in terms of broader issues, e.g. waste management, there is a lack of clearly observable actions that are currently implementing long-term pro-environmental visions on a sort of "step by step" basis with the goal of getting results on a wider scale and working over a considerable time perspective. The efforts that are being undertaken by many large cities are of course in line with the vision of urban efforts (including the waste management system as one of the elements of a city's pro-environmental policy), but they are often not tied to a broader, pioneering idea, but projects that are either a consequence of other efforts and dependencies (e.g. the adaptation of the policy of cities in European Union member states to its directives) or of a need to solve an emerging socio-economic problem.

3. Analysis of thermal waste processing plants in Italy

One of the countries which have faced the necessity of rapidly solving the problem of waste management is Italy. On the one hand, this has been caused by the necessity of Italy to adapt - like any EU member state - to EU requirements, while on the other (to a much greater degree), with the need to solve the urgent problem of the neutralisation of municipal waste, mainly in the cities of southern Italy, and the associated threat to the lives of the residents of some regions. The model example of the necessity of finding a quick and effective means of solving the problem of municipal waste management is the region of Campania, with its capital, Naples. This area constituted the subject of the case study and has been discussed further in the article. The improper waste management in the northern part of the country (mainly industrial waste), as well as municipal waste in the south of Italy, led to a situation in which, both in terms of the efforts of the public and private sector, new solutions had started to be sought. The problem peaked (in the form of an escalating danger to the health of residents and an open social conflict in Campania) in the years 2008-2010. At the time of the writing of this article there were 59 functioning thermal waste processing plants in Italy. These were both newly built buildings, constituting a direct answer to the problem of the country's municipal waste management, as well as those that constituted an answer to meeting the requirements of EU directives, in addition to such thermal waste processing plants that had been built in the previous century and
were being modernised for the aforementioned reasons. The table below presents the number of eco-
incineration plants in each of Italy's regions, with a division in terms of the technology that they
employ (table 2).

Table 2. The number of thermal waste processing plants in Italy, divided by region and the type
of employed technology, original work based on [3], [4].

| Region:       | Installation type: |        |        |        |        |        | Total: |
|---------------|--------------------|--------|--------|--------|--------|--------|--------|
|               | Movable grate      | Rotary kiln | Fluidised bed | Gasification | Pyrolysis | Other/ mixed | No data |        |
| L’Aquila      | -                  | -       | -       | -       | -       | -       | -       |
| (Abruzzo)     |                    |         |         |         |         |         |         |
| Puglia        | 1                  | -       | -       | -       | -       | -       | 1       | 2      |
| Basilicata    | -                  | -       | -       | -       | 1       | 1       | 2       |
| Valle d’Aosta | -                  | -       | -       | -       | -       | -       |         |
| Emilia-Romagna| 8                  | -       | 1       | -       | -       | -       | -       | 9      |
| Friuli-Venezia| 1                  | -       | -       | -       | -       | -       | -       | 1      |
| Sardegna      | -                  | -       | -       | 1       | -       | -       | -       |
| Calabria      | -                  | -       | 1       | -       | -       | -       | -       | 1      |
| Campania      | 1                  | -       | -       | -       | -       | -       | -       | 1      |
| Lazio         | -                  | -       | -       | 1       | -       | 4       | 5       |
| Liguria       | -                  | -       | -       | -       | -       | -       | -       |
| Lombardia     | 9                  | -       | 1       | -       | -       | 3       | 2       | 15     |
| Marche        | 1                  | -       | -       | -       | -       | -       | -       | 1      |
| Molise        | -                  | -       | -       | -       | -       | -       | -       |
| Piemonte      | 2                  | -       | -       | -       | -       | -       | 1       | 3      |
| Sardegna      | -                  | -       | 1       | -       | -       | 1       | 2       |
| Sicilia       | -                  | -       | -       | -       | -       | 1       | 1       | 2      |
| Toscana       | 7                  | -       | -       | -       | -       | 1       | 2       | 10     |
| Trentino/Alto Adige | 1 | -       | -       | -       | -       | -       | -       | 1      |
| Umbria        | 1                  | -       | -       | -       | -       | -       | -       |
| Veneto        | 2                  | -       | -       | -       | -       | 1       | 3       |
| **Total:**    | **34**             | **4**   | **1**   | **-**   | **-**   | **12**  | **8**   | **59** |

Thermal waste processing plants were taken into consideration in the analysis presented above,
however, in some cases the listing also includes those structures that incinerated other types of waste,
but produced energy for a nearby city, and their operation was heavily linked with propagating pro-
environmental efforts in their region. Based on the above listing it can be observed that, similarly to
the situation present in many European Union member states, the most commonly used incineration
technology in Italy was determined to be that of the movable grate (over half of all analysed
installations). Simultaneously, of note is the fact that in the group of mixed technologies (a structure
had several incineration lines based on different technologies), at least one was a movable-grate-based
line. In solutions featured in Italian thermal waste processing plants there were no reported uses of
pyrolysis or rotary kiln technologies, while gasification was introduced in only a single plant. When
analysing the results in terms of territorial division, it was observed that there were more thermal
waste processing plants in the northern, economically well-developed areas (e.g. Lombardia or Emilia-
Romagna), than in the less developed south (Calabria, Campania). This, of course, is not a rule, as other factors need to be taken into account, such as the size of each region or accessibility to these types of structures in adjacent regions, etc.

Based on the data that had been gathered, the author performed an analysis showing in what years had thermal waste processing plants been built throughout Italy and at what intensity (table 3).

Table 3. Currently operating thermal waste processing plants in Italy - years of entering service, original work, 2018

| Prior to 1990 | 1991-2000 | 2001-2008 | 2009-2018 | No data |
|--------------|-----------|-----------|-----------|---------|
| Number of plants: | 8         | 14        | 23        | 9       | 5       |

The analysis presented above took into account thermal waste processing plants that were operating at the time of the performance of the study. The dates of the plants entering service were divided into four periods:

- Plants that entered service prior to the year 1990. These are plants that were mostly built in the 1960's and 1970's, before the discovery of the harmfulness of dioxins, which are a product of waste incineration.
- In the final decade of the twentieth century - the period when, as a result of heavily funded scientific research and a modernisation of exhaust purification systems, the harmfulness of exhaust produced by incineration plants was significantly reduced, and has proven successful. In Italy it was also a time when the problem of waste management started to become noticeable, for instance in Campania.
- The years 2001-2008 were a period of social tension throughout Italy due to the management of municipal and other types of waste, which resulted in a crisis in Campania lasting several years afterwards.
- The period of the last ten years was a time of a particularly intense environmental and social conflict (particularly in the area of Naples), which was followed by an attempt at relieving social tension in terms of waste management in Italy.

The analysed structures were divided into groups according to the period in which they started to operate. However, in order to compare actual efforts in the field of waste management to pro-environmental ideas, but mainly to cases of emergent necessity, a certain modification was introduced. Those structures which (despite entering service early, for instance in the 1970's or 1980's) had been completely redeveloped not only in terms of the modernisation of individual technological lines, but also of the operation of the entirety of the plant and oftentimes with a complete redevelopment of their form - were classified as belonging to the time group during which the latest intensive modernisation had taken place. One example of such a plant is the one in Padua. During the analysis of the results, the length of the development process also had to be taken into consideration, as it had been different for each thermal processing plant. The fact that in some cases the decision regarding the necessity of making efforts towards the construction or redevelopment of a waste processing plant had been made in one period discussed in table 3, while the actual start of the plant's operation commenced in the successive one also needed to be taken into account.

The table also does not contain those structures which were at the construction stage or the stage of making binding placement decisions at the time of the performance of the study. After taking into consideration the conditions stated above, it was possible to observe that up to 40 percent of all eco-incineration plants operating in Italy began their operation during the first eight years of the twenty-first century, which is the period when the first successes in terms of the effective purification of volatile fractions were made. The number of plants that started operating during the final decade of the twentieth century amounted to 24% of all plants. The first period being discussed, i.e. prior to the year
1990, included only 14% of the plants. A slightly more numerous group (15%) was made up of plants that commenced their operation in the last decade, which is associated with a certain saturation of urban structures with such plants and a lower demand for them. It can be concluded that these tendencies are in line with general European trends, however, Italy still remained a country whose needs in terms of the construction of such structures were not 100% fulfilled (in contrast to, for instance, Germany, or some Scandinavian countries).

4. Case study - the problem of waste management in Campania

Campania is one of the twenty administrative provinces of Italy, bordering Lazio and Molise from the north and Apulia and Basilicata from the north east and east. The region has an area of 13 595 km² and a population of over 5.7 million people, of which 1.2 million constitute the population of Naples [5]. It is also the most densely populated region in Italy (419 persons per km²), which, in the face of the problem of waste management, the threat to the health of the residents that produces effects after a long period of time and a direct epidemiological threat in Naples itself that are being discussed - underlines the scale of the problem. At the same time the basis of the local economy, apart from tourism, is agriculture, and some areas of the region have been called the "green lungs" of southern Italy for a long time. In the years 2008-2010, when the problem of waste management in Campania started to get worse, there was a total of 150 places covered by various forms of protecting animate and inanimate nature, including 4 State Natural Reserves, in the region [6].

The problem of environmental pollution associated with dumping waste in Campania has had its beginning in the middle of the 1990's. It was then that the lack of appropriate waste management became evident. The downplaying of worrying practices associated with the transport and illegal dumping of waste from industrial plants from northern Italy in Campania, the lack of proper waste management practices and the lack of appropriate and sufficient infrastructure that would make it possible to process (as much as possible) and deposit (only in necessary and safe amounts) municipal and other types of waste constituted the basis for a many-years-long environmental, social and economic problem in this region. The shutting down of the largest landfill near Naples in 2007, which was followed by the shutting down of two additional ones, resulted in a significant social, ecological, economic and political conflict. On the one hand, municipal waste ceased to be transported outside of Naples and remained on the city's streets, while on the other, illegal landfills for waste transported from outside started to appear in Campania (in addition to southern Lazio).

The attempt at solving the problem resulted in feigned action on behalf of the authorities, destroying both public trust (unfulfilled promises of the construction of three environmentally friendly thermal waste processing plants, concurrent proposals of demarcating areas for new landfills within areas under legal protection - including within the borders of the Vesuvius National Park, etc.), in addition to negating the effects of pro-environmental efforts which the residents of Naples started to undertake themselves as they saw no results (the promotion of the segregation of waste which in the end was not even collected from them, etc.).

The lack of efforts to keep the city clean led to tons of municipal waste to lie on the streets of Naples, leading to a situation in which the lives and wellbeing of the residents were under threat, and which was comparable to the threat of the plague in the seventeenth century. Similarly, the shutting down of overflowing landfills and unfavourable agreements accepting industrial waste from northern regions of Italy caused the agricultural and protected areas of Campania to become sites of the illegal dumping of waste (also of the dangerous kind), leading to a direct and indirect threat to the lives and wellbeing of the population. The publicising of research published in 2003 [7] which had tied the increase in the number of deaths associated with the occurrence of liver cancer with living in areas particularly suffering from pollution with waste (fig. 1) led to the performance of further studies.
The proving of, among other things, significant water, soil and air pollution in this area, as well as publicising the fact of the increase in the amount of deaths associated with liver cancer from 15% (the average for Italy) to 40% (in the region being discussed), resulted in vocal protests among the residents both against of the placement of new landfills, as well as the lack of the authorities' reaction to the illegal depositing of waste and its burning [8]. The environmentally friendly municipal waste incineration plant that began operating in Acerra in 2009 (fig. 2) constituted only a partial solution to the problem. It is a structure that has three technological lines, which operate using movable grate technology, and is fitted with 7 independent installations for initial waste processing before its incineration and for composting.

The thermal waste processing plant accepts municipal waste from the entire region of Campania, provided it meets the quality criteria that allows it to be processed. With a power of 107,5 MW, the plant is capable of incinerating 600 000 tons of municipal waste per year. From an architectural point of view, the structure undeniably dominates the surrounding space and has been designed with adherence to the principles of the art of architectural design. The plant, due to its location near the SS7bis motorway, is well connected both to Naples and other areas of the Campania region. The structure is located on plots belonging to the Italian Ministry of Defence.

It is located in an open area, in the vicinity of a developing industrial and commercial zone. In the case of the problem of the depositing and the lack of the ability to process municipal and other types of waste in Campania that is being discussed, the thermal municipal waste processing plant in Acerra - as has been mentioned above - has proven to be only a partial solution to this problem. The region's authorities of the time undertook a series of efforts in order for broadly understood pro-environmental activities and the new manner of waste management to have a multidimensional scope on the regional scale.

Apart from efforts undertaken directly on-site, the ability to ship waste to the Netherlands, where they were processed by, among other facilities, the incineration plant in Rotterdam, was seen as a significant and innovative solution in 2012. Such efforts were proven to be effective, at least partially
averting the environmental, social, political and economic conflict. They also provided a good example that when waste management is performed appropriately, the final element of the idea of the Circular Economy - which is waste itself, that needs to be processed - can constitute an additional source of energy, among its other uses.

Figure 2. The thermal waste processing plant in Acerra near Naples, photo by the author, 2017

5. Conclusions and observations

The topicality of the subject of waste management is constantly being confirmed by the existing need for such efforts. Numerous examples of the construction of thermal waste processing plants both within cities that planned such a project due to environmental-protection-related and other considerations, as well as those which were faced with the urgent need for finding such a "here and now"-type solution. The following conclusions and observations were formulated based on the research:

- In terms of pro-environmental efforts concerning waste management, the role of society and the authorities that perform actions in order to increase awareness of this subject is of particular significance. This applies both to the subject of waste segregation, raising awareness of the significance of the residents' involvement in this process, as well as broadly understood environmental awareness. The example of Naples has shown how significant the role of residents is (both in terms of their actions, as well as, conversely - their inaction), as well as the broad reaction in terms of the public reception of both positive efforts by authorities, as well as neglect on their behalf.

- A large number of built incineration plants does not mean that needs considering waste processing are being met. The effectiveness of these eco-incineration plants, the technology they employ and the broad range of incinerated types of waste, adapted to actual needs, is of much greater significance. The construction of an eco-incineration plant must be directly adapted to both current and prognosticated needs. It is necessary to find a balance between the actual need for constructing a thermal waste processing plant and the mere existence of such a possibility. The construction of plants that do not fully and
directly address a given need generates problems and is negatively received by the public, undermining the sense of such projects.

- The majority of the plants analysed in this article was not built in accordance with far-reaching visions, as they were the result of a need - in some cases of a need defined on the basis of broader regional needs, while in others of an urgent necessity.

- In terms of waste management, visionary approaches are often extraordinarily far-reaching. This is good, because they can set a course for actions in a broader perspective. Doing so is one of the fundamental tasks of science. On the other hand, we are dealing with efforts that are meant to solve urgent problems of the "here and now" type. Thus we can observe that there is often a lack of plans for efforts that could address the "necessity of today" in relation to "far-reaching visions". There is also a sort of a lack of efforts that could bridge the gap between these two methods of approaching the problem.

Based on the analyses that were performed, it can be concluded that efforts towards the construction of eco-incineration plants are most often the result of necessity. However, from an architectural, urban planning and planning-related perspective, it must be stated that it is often this necessity that shapes vision. The construction of spatially attractive plants that visually improve the quality of a place, mostly in such areas that are visible from a broader perspective (e.g. entryways into a city) is often a basis for a good perspective and further good ideas and spatial actions. They are the first step in the direction towards emerging possibilities. These often include convincing the authorities of a city, as well as its residents, that structures with municipal engineering functions can be attractive, significant and can improve the quality of the space within which they are located.

It can be concluded that in the case of thermal waste processing plants, from an architectural perspective, we are more and more often encountering the direction "from a necessity to a vision", and not the other way around.

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