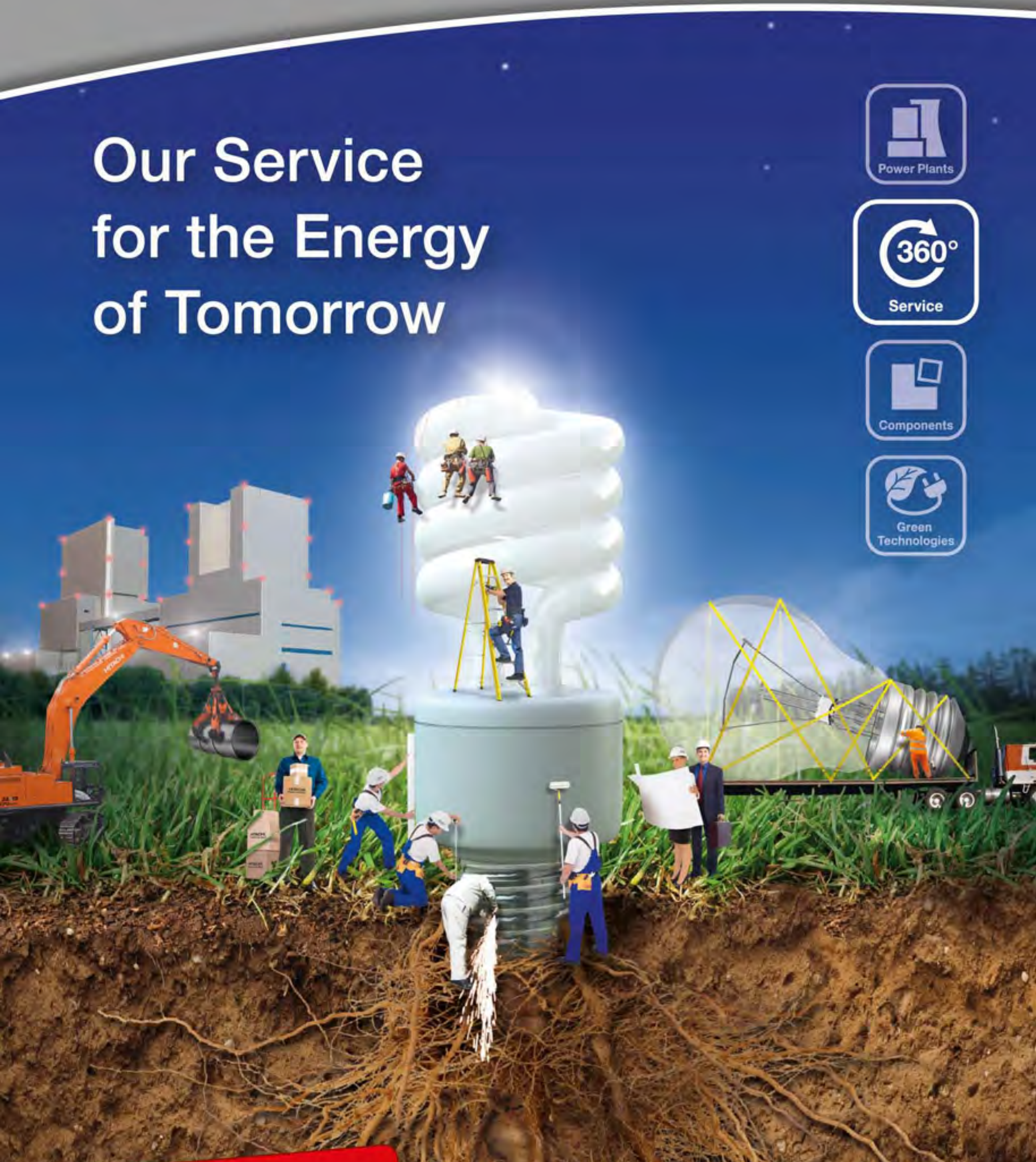
MH POWER SYSTEMS EUROPE SERVICE

Our Service for the Energy of Tomorrow



MH Power Systems Europe Service GmbH
is the successor company of Hitachi Power Europe Service GmbH

www.service.eu.mhps.com

As internationally leading provider of services all around energy and power plants, we are bundling the service activities of Mitsubishi Hitachi Power Systems Europe GmbH. Our focus is on the preservation and continuous optimisation of existing plants and their components – including the supply of any and all spare parts.

Waste Availability, Successful Regional Strategies and New WtE Projects Shaping

– The Benefits and Application of the Optimization Tool NERUDA –

Martin Pavlas

There are more than 2,000 waste-to-energy plants (WtE) in operation worldwide. Only in Europe are there facilities with an overall processing capacity of around 100 million tons [1]. These are mainly located in Western Europe and their erection took place between 1980 and 2000 when these countries were in the process of transiting their waste management systems into more efficient forms. Even though 120 million tons of municipal solid waste (MSW) was still landfilled in 2010 in EU [2], the outlook for new plants within Europe in this decade is pessimistic. There are only a number of several new plants planned and the centre point of future construction has shifted to Asia [1].

It is expected that this negative outlook would not change even though the majority of EU countries, mainly those from Central, South and Eastern Europe, have promised a gradual decrease in biodegradable waste landfilled by 2020. Even though this future obligation exists, it looks as though the current driver stipulating investors' activity to turn the projects from planning into their implementation phase is missing. The shift towards more efficient utilization requires the design of intelligent regional strategies and investors' willingness to build and operate new incineration plants at the same time.

In general, a strong political determination to change legislation related to waste management and to implement key economic instruments is missing in many countries. These changes could discourage cheap landfilling and encourage more sustainable forms of waste treatment in compliance with directive 2008/98/EC. An overview of landfill taxes and bans across Europe is provided by CEWEP as they are in place or are planned in near future. Since it is regularly updated it provides the latest data. In countries like Bulgaria, Czech Republic, Estonia, Finland, France, Greece, Hungary, Romania and the UK, important changes are expected this year or in 2015 and 2016 to establish other methods of MSW treatment. The same document monitors current average gate-fees at landfills. Current gate-fees at landfills were analysed in report [3], where the correlation between a decrease in landfilling and landfill tax is highlighted. Particular projects have to be implemented and lead to their successful operation to turn the selected strategy into practice. The following conditions should be met from the investor's point of view:

- An acceptable risk of the project, waste availability at gate-fees providing satisfactory project economy and return on investments
- The support of stakeholders.

Present unstable conditions and an unpredictable future outlook do not contribute to any of above mentioned points. Particularly, unforeseeable energy prices stimulate project risks. Consequently, opponents of WtE make use of this situation to strengthen their positions. In this context, earlier general arguments against WtE addressing the harmful impacts on the environment and health are wisely substituted by locally focused statements about the future redundancy of particular projects. By this, the so called Not-In-My-BackYard – NIMBY – effect is supported. Specific claims are as follows:

- Waste generation is decreased, the problem will be solved by highly efficient separation and recycling, WtE obstructs progress in recycling.
- WtE has minimum impact on environment but is too expensive. The increase in the price of service provided to the citizens will be unbearable. The processing prices in Western Europe are falling as a result of a developed overcapacity, but municipalities bound in long-term contracts cover the missing contribution margin. Therefore, there is a cheaper and more advantageous solution based on mechanical-biological treatment (MBT).

In summary, it is a dynamic world and an unforeseeable future outlook with a combination of large infrastructure project planning taking several years make the decision process even more complicated. Generally, there is a lack of compelling arguments for new WtE projects. This contribution deals with the recent important issue of a possibility to simulate future changes in waste flows at regional and/or international level which could support decision making in this field. Special attention is paid to residual waste – waste which cannot be recycled and therefore is subject to thermal processing with energy utilization – and the promotion of its sustainable utilization by WtE. The prediction of waste availability in coming years represents a challenging task for both policy-makers and operators. Uncertain future changes in the population, waste production by households and the share and exploitation of marketable forms of recyclables have a direct influence on residual waste availability and its transport in the region.

1. NERUDA – a sophisticated tool for the simulation of waste flows in a selected region

For the reasons stated above we have developed a sophisticated computational tool, NERUDA, which can be used for the simulation and optimization of waste flows from its sources to disposal sites in the selected region. This tool is based on a comprehensive mathematical model (logistic problem minimizing the total cost), which is applied to a network with existing infrastructure obtained from a geographical information system (GIS). It is based on a simple principle implemented in a complex problem (see below). First, let us shortly summarize the outstanding features related to the practical use of this unique computational tool:

- It optimizes waste treatment strategy in a specific region from the waste producer‘s point of view (regarding economics and environment). The region of focus is divided into nodes, the number of which varies according to the specific application but typically ranges in the hundreds. Such an approach allows us to simulate waste flows between producers and key-components (WtE, MBT, landfills, see Figure 1). By this, the unified waste market is simulated and interactions related to a competitive environment are addressed. In this context, waste availability is used as the parameter for a proposal for new processing capacities‘ location and their size.
- It integrates waste-to-energy facilities within the energy concept of cities – heat delivery influences plant economy and cogeneration as the most effective way of utilizing energy with a positive effect on primary energy savings (which is promoted wherever applicable).

Following on from a recent overview from 2014 [4], such a comprehensive and practically available tool is missing. Currently available models dealing with these subjects are often simplified, insufficiently interconnected and of very limited practical contribution.

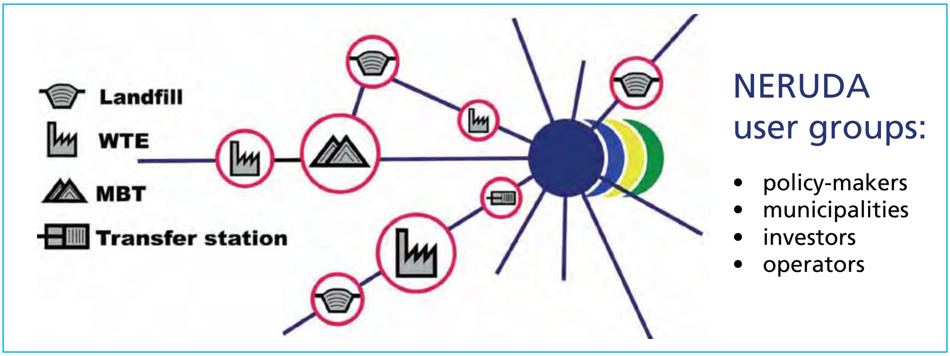


Figure 1: NERUDA – one tool and comprehensive results presentation according to a customer‘s demand

A treatment strategy is proposed with the goal of minimizing treatment costs in the whole region. Therefore the basic idea behind the NERUDA tool is as follows: Each of waste producers in the region makes a decision about where to treat their waste.

The objective function addresses expenses in terms of cost for waste processing at individual facilities and overall cost of the transport to the facilities. Environmental taxation, as a dominant financial instruments and sensitive political issues at the international level, is included as well and reflected in the price of processing. This simple principle (*idea)* is then modified (*hand-tailored*) according to an application which encompasses (Figure 1):

- Concepts at regional and countries level
- The feasibility of investments in waste-to-energy
- Waste transport optimization
- Unified waste market modelling.

The basic mathematical model standing behind this tool is described in detail in [7]. Naturally, countries and regions, where conceptual planning of waste management systems is a current issue in order to redirect waste flow from landfilling, can contribute to such a computation. In the next two sections of this contribution, the benefits of NERUDA are presented through practical examples which come from its application in a specific region (the Czech Republic - CZE).

2. Simulation as a supporting tool for capacities planning at regional level – A case study

In 2013, NERUDA was applied to analyze the future demand for new WtE facilities in CZE. First, let us briefly mention the situation in CZE and present the latest data available related to waste management in 2012. With an area of 78,000 km^2 and a population of 10,5 mil. inhabitants, the country generated 5.2 mil. tons of MSW (i.e. of waste produced by households and similar waste generated by small enterprises and public institutions), which leads to the specific production of 495 kg/cap and year. 42% of this amount was recovered, of which thirty percent and twelve percent (624 kt/y) was material recovery and energy recovery, respectively. 54 % (i.e. 2,800 kt/y) is still landfilled. There are three WtE plants in operation with a total capacity of 645 kt/y. All running facilities implement cogeneration, where the heat leaving turbines is supplied to district heating systems. This makes the plants very efficient (R1> 0.65). One more project with a capacity of 95 kt/y located in a suburb in the City of Pilsen is currently under construction with planned full operation in 2016. A few other projects are in the early stage of their development (conceptual planning).

Since the current average cost of landfilling is approx. 40 EUR/t, which is a very low price to make WtE competitive, investors are waiting for increased taxation stipulated by legislation. As announced by the responsible ministries (situation relevant to April 2014), besides waste prevention and recycling promotion, the economic principle focusing on residual waste should be as follows: (1) a total ban on landfilling untreated waste should be in place from 2023 to provide the necessary time for infrastructure development; (2) In the meantime, the landfill tax will be gradually increased.

Logical questions related to the issue are as follows: (1) How many WtE plant should be operated in CZE in the future? What economic drivers are inevitable for the sustainable operation of these plants? How much waste-based energy can be delivered from these plants?

The future situation in 2025, with the presumed ban on landfilling, was considered. The potential for heat delivery within existing district heating systems was addressed. To solve this task, the advantages of NERUDA tool were fully exploited. In this specific application, the CZE region was divided into 220 subareas – the level of detail corresponds to county level cities, which were considered as single points creating the interconnected network.

First, necessary data were gathered at each point, especially with the aim of predicting waste production in 2025. In this context, data on waste suitable for thermal treatment (residual waste, bulky waste, industrial waste) and waste not materially recovered in 2012 was taken as a baseline. This amount reached 3,500 kt/y in 2012. A set of future scenarios of rates were considered covering wide range of annual changes (from minus two percent up to plus two percent).

Next, treatment capacities were permitted for evaluation in convenient nodes. There are 13 locations for WtE plants – three existing, one currently in construction with full operation in the year of calculation, and another nine new plants – with a maximum aggregated capacity in the calculation of 3,560 kt/y – this value approximately meets the current production of combustible waste. The locations for new WtE plants were mainly in or close to cities with large district heating (DH), where the annual heat demand ranges from 0.4 to 10 PJ/y. The integration of WtE plants within an existing heating plant is a crucial aspect since 35 % of households and 50 % of citizens are supplied by DHs. Annual heat delivery within DHs reaches 200 PJ, which is 54 % of total heat consumption. Regarding fuel, 84 percent of energy consumed by DHs comes from lignite (130 PJ/y).

Therefore the motivation is not only to dispose of the waste but also to produce heat from domestic renewable fuel and by this to cut down on the fossil fuel consumption. Moreover, heat dispatch represents a vital income and makes the project competitive at the same time. In this context, it provides power to offer an acceptable gate-fee and by this to secure enough waste for its operation. This pattern meets current expectations about new projects as planned by investors.

WtE was not considered as the only option. Despite the future landfill ban, all landfill sites with sufficient free capacity in 2025 were included. These capacities were permitted to handle the residual fractions (low calorific value materials) generated by MBT. In general, more than twenty percent of the input flow entering MBT is transferred into these streams [9]. Secondly, important output from MBT, refuse-derived fuel (RDF), is supposed to be co-incinerated within the existing energy producing facilities – mainly combined heat and power plants – and/or in cement works. These processing capacities were set in particular nodes. Considering these capacities, the maximum amount of waste processed by MBT was assessed to be 1,200 kt per year.

Transportation costs represent another important aspect influencing results. It can be considered as a function of distance and NERUDA can cope with road and railway transport. For both systems, separated map backgrounds can be added. If required, NERUDA proposes locations for transfer stations, where the waste brought by single collection vehicles is compressed into containers for its holing to remote disposal sites by trucks or trains. As stated e.g. by [8], long-distance transport up to 1,000 kilometres is possible around the price 50 to 60 EUR/t. Regarding the current situation in Western Europe, the cross-border transport from CZE to Germany and Austria was considered as an option in our case study.

During the main calculation, each of nine intended plants were tested for a maximum reasonable – acceptable by stakeholders – capacity; i.e. up to 200 and 400 kt per year for projects in localities with smaller and large DHs, respectively. At the same time, future expansion in the capacity of the four existing plants was considered as well. For each new plant, a gate-fee providing an attractive plant economy was generated prior to main simulation – the so called pre-processing phase. This was done by extensive heat and mass balancing and financial assessment considering specific features of the locality. Since different capacities were considered, capacity-dependent gate-fee functions reflecting varying heat delivery and future development of prices were obtained.

For one scenario (see below) including these inputs and considering all 220 nodes simultaneously, NERUDA proposed an optimum arrangement of capacities and waste flows, where the lowest processing cost for all nodes was obtained. In fact, the set-up has the lowest financial impact on the final users – citizens.

The target facility, to which the waste is shipped for its disposal (i.e. WtE in CZE, WtE abroad), was proposed for each node. In specific scenarios, some WtE plants were not recommended for implementation and were denoted as risky and therefore unattractive. Additionally, MBT were proposed if feasible and their capacities were recommended. The condition for landfilling residual stream had to be met. At the same time the treatment capacity for RDF produced has to be connected, therefore no accumulation is allowed. By this the processing chain is completed.

The amount of waste which comes from different localities (nodes) determined the optimum capacities – from the facilities' point of view. Furthermore, overall heat delivery to DHs and power production was evaluated at the national level

The calculation is influenced by a number of uncertain parameters, the future value of which can be predicted only with difficulty. On the other hand, these influence waste availability, plant economy, plant competitiveness and energy production and therefore have to be handled in some way. In this study, uncertain parameters have been divided into two groups:

- Key parameters (Group 1) – waste production in 2025, gate fee in foreign WtE plants in 2025
- Important parameters (Group 2) – gate-fee provided by every included project (WtE as well as MBT), transportation costs, etc.

Parameters from Group 1 were reflected in a scenario, i.e. a sensitivity analysis was performed. Parameters in Group 2 were treated by Monte Carlo simulation, i.e. stochastic simulation using values generated from specific range using normal distribution function. The treatment method has a direct influence on the subsequent results processing and visualization (Figure 3). One of many simulation results is represented in Figure 2, where waste streams distributed between key-components – WtE plants and mechanical-biological treatment plants – considering future landfill banning is shown.

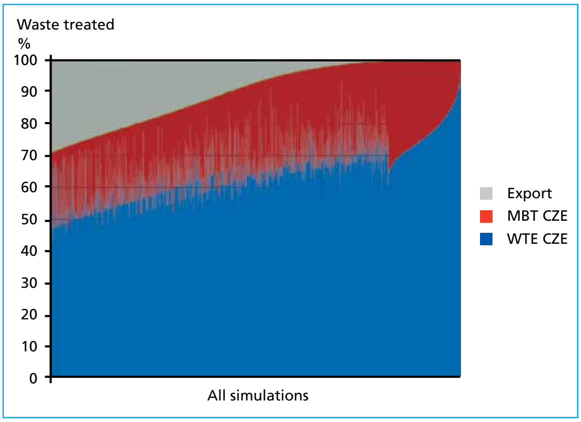


Figure 2:

Varied share of residual waste treated in 2025 by WtE or MBT plants or exported for its energy recovery as predicted by NERUDA tool

Whereas Figure 2 provides us with a first insight into the problem, the second Figure 3 shows more detailed information after the data were statistically processed (post-processing) to present and analyze the influence of uncertain parameters on the results. The parameters from Group 1 are changed on the horizontal axis. The influence of parameters from Group 2 is visible from the shape of the distribution function, which is characterized by percentiles (Figure 3).

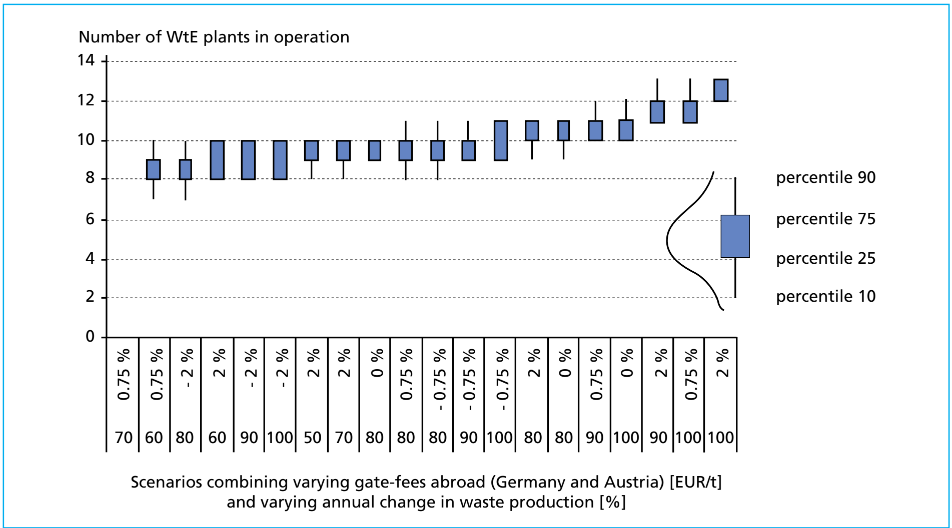


Figure 3: Number of WtE plants in operation after 2025 as a result of stochastic simulation, where different scenarios of uncertain parameters were included

Many other graphs can be generated in a similar way, including gate-fee distribution, collection areas, average distance, average treatment cost for producer, aggregated data of power production etc.

The calculation proved that waste incineration with heat utilization represents a key component for a successful waste management system in the CZE. MBT is denoted as a supplementary option due to the combination of limited RDF fuel exploitation and an unstable economy. This technology is sensitive to future change in key parameters. The analysis also revealed that without any support on investment or without subsides for energy produced in WtE, a considerable amount of combustible waste could be transported for its energy recovery abroad (to Germany, Austria). Therefore, in the second part of the study, the sensitivity of the results was tested with the aim of supporting the on-going discussion about how to preserve renewable source at home to maximum level. The results are not presented in this contribution.

The second example comes from an application of NERUDA during the conceptual planning of a particular project in a specific locality.

3. Risk-analysis for a specific WtE in its conceptual development stage

Waste availability and related income from waste processing represent key aspects for the sustainable operation of every WtE plant. Therefore, computation to determine prices at which waste is available in a sufficient amount to fulfil the intended plant‘s capacity is an integral part of a comprehensive risk analysis. Such analysis, which is briefly introduced in this section, was performed using NERUDA. Different scenarios associated with risks were evaluated.

First, the desired gate-fee is determined from a comprehensive cash-flow analysis, it is affected by other incomes and costs and their future unpredictable escalations. This is more and more important in the current dynamic world (volatile energy prices etc.). One of the key elements in such an analysis is heat delivery to third parties – i.e. residential heating via district heating systems or integration with industrial utilities – and related trends in amounts and prices. Secondly, the gate-fee has to guarantee the competitiveness of the project in terms of fulfilling the designed capacity. For this point, the investors‘ expectation does not have to overlap with conditions in future market.

Whereas in the previous example in section 3, the capacities were the subject of analysis, in this case we go one step further in the assessment. The capacity is now fixed, in our specific case at 200 kt per year, and the task is to determine a competitive gate fee which can secure enough waste.

Such as analysis is useful for convincing all stakeholders that the project is robust and sustainable and can survive even in bad conditions. Since the possible risk is always cascaded down to the final user of the service, i.e. *the citizen pays the bill*, we can assume, that only those producers who get the cheapest alternative will participate in the project and will deliver the waste. In general, the same principle of minimizing total costs for all producers can be applied. The idea of the calculation is as follows: at the early stage of project development, there are many risks associated with the future development of a competitive environment. Since we cannot exclude other projects being established (MBT, other WtE plants), we have to be prepared for future interference. Because of this, extensive *What – If* analysis is performed. The analysis is tightly bound with a generally valid relationship between demand and offer patterns. In our case this pattern is represented by waste production (waste availability) and the overall capacity of running plants. The phenomena of this pattern and its consequences on the plant economy are mentioned by [6], where an extensive analysis is provided which focuses on future overcapacity prediction in different geographical parts of Germany. The contribution demonstrates the expected decrease in processing costs for industrial waste from 70 EUR/t down to 50 EUR/t also.

In our case study based on the discussion with the investor the following seven risks (R) were listed and subsequently evaluated:

R1– other projects will expect a lower return on investments (municipal projects), R2 – low processing prices will be offered abroad (Germany, Austria), R3 – the production of residual waste will be significantly decreased as a consequence of increased material recovery, R4 – legislation will be favorable to MBT (residual and calorific flows can be treated under less strict conditions), R5 – decreasing prices for landfilling as a consequence of lower profits, R6 – the majority of waste will have to be transported by trains, R7 – heat prices will increase. In general, all risks when active have a negative influence on waste availability as the most important risk and put pressure on the evaluated plant in terms of its necessity to decrease its gate-fee.

The procedure was as follows: to be able to quantify each of potential risks a parameter denoted as a risk factor was defined for each qualitative risk. Subsequently two values of risk factors were defined. The first value is considered as highly probable since it corresponds to the current situation and to the foreseeable future development (green values in Figure 4); the other value describes a future situation with very low probability but with a serious impact. So it should not be excluded (red values in Figure 4). Combinations of risk factors shape different scenarios. These scenarios were subsequently entered the main NERUDA calculation.

To demonstrate the benefits, one of many results is provided in Figure 4. It shows the sensitivity of the gate-fee on scenarios. The results are valid for landfill tax 100 EUR/t and the gate-fees are displayed in descending order and in relation to the average value. Therefore, the serious risks are accumulated in the right part of the illustration.

This was repeated several times for varying landfill taxation and provides us with a set of similar graphs. The data can be used to evaluate the serious risks and quantify their impact. In this case, the analysis confirmed the robustness of the project, as the main risks have been evaluated the R1 and R2. For example, regarding risk R1, if the gate-fee abroad decreased from 80 EUR/t to 55 EUR/t, the expected revenue would decrease by an acceptable 15 percent (R1). Since the knowledge of gate-fees provides input for further economy assessment, the analysis helps the investor to make a decision about the project. At the same time they can make a trade-off between risk and their anticipated profitability.

Figure 4: Results of a comprehensive risk analysis, where an acceptable gate-fee for securing waste to fulfil the capacity is tested against a combination of different risks

4. Other applications and unified waste market modelling

The previous two case studies presented the contribution of our tool for decision-making in waste management and the conceptual design of intelligent regional strategies. The application is not limited and various modifications of NERUDA tool can optimize collection areas, the collection of waste commodities, finding a location for transfer stations and deciding on their size. The model is easily extendable for railway connections so a proposal for the suitable technology for waste transport from producer to processor (road – railway – intermodal system) can be made.

Unified Waste Market Modelling

So far, NERUDA has been used for countries with a developing waste management in order to meet their commitments to reduce the rates of biodegradable waste landfilled. However, countries with well-developed waste management, characterized by high shares of material recovery and incineration, are also good candidates for similar calculations. Here, the general goal is to reach an effective exploitation of the existing capacities. This is important, as mentioned above, because a processing overcapacity was recently developed in countries such as Germany, Austria, Netherlands, Denmark, etc.

Future changes in the population, the production of household and residual waste and the expected increased share of marketable forms of recyclables will have a direct influence on residual waste availability. With increased competition in this market, the importance of waste transport will increased as well. Waste can be transferred over longer distances for its energy recovery today. The main streams in cross-border transport of waste within Europe were summarized by [8]. One frequent flow is from Italy to Switzerland, Austria and Germany; from the UK to Continental Europe and to Scandinavia. The situation in UK is of great importance since new facilities are under construction and once these are in operation, changes in waste flows across Europe are expected as well.

Due to legislation (EC Regulation No 1013/2006), this cross-border activity is possible if energy recovery conditions are met, i.e. if the condition of minimum Energy Efficiency (R1) in target facility is met. As follows from a comprehensive review presented by Reimann [5], the efficiency of energy utilization in countries with lower annual temperatures is significantly higher. This justifies the long-distance transport of waste from south to north.

On the other hand, cross-border shipment is subject to regulation and is obstructed by permissions. Therefore, the idea of introducing a *Shengen for waste* has been largely discussed.

Moreover, waste transport is emphasized because of the uneven implementation of economic instruments (i.e. landfill and incineration taxation) in individual regions. Policy-makers see taxes on landfill and incineration as an ideal tool for managing waste streams. The mechanisms and side-effects of such taxes are being debated across Europe. Let us briefly mention the famous case of waste transport on the Norwegian and Sweden border. Norway's incineration tax was introduced in 1999 and Sweden's in 2006, which consequently led to the transport of more than 600 kt of waste from Norway to Sweden, see [10]. The waste was utilized for heating purposes in district heating systems. The request for local utilization of waste, as source of renewable energy and source of secondary materials led to scraping the taxation in both countries in 2010.

The example shows that such an environmental taxation can be effective only when the country (region) is isolated from neighboring countries. This is not case in the EU where a unified waste market is present. Despite this negative experience, environmental taxation is considered in many EU countries which justifies the implementation of a modelling approach and the assessment of environmental and economic impacts of such regulation.

For these reasons, the application of NERUDA as a tool for a geographical area including more than one country is the current issue. Modelling the impact and development of key parameters in individual EU countries (production, capacities, environmental taxes) on the effective utilization and planning of WtE capacities is the priority.

The following web page nerudawasteflow.pbworks.com provides an open user-friendly wiki-based communication platform, where data related to many regions of the EU are summarized. It provides a discussion forum focused on the future application and future development of NEUDA as well. Therefore it can be understood as a starting initiative promoting the application of the tool on the European level.

5. Conclusion

The tool NERUDA, which is a complex transportation model implemented in a specific field of waste management, is introduced in this contribution. It can be used for the conceptual planning of intelligent regional strategies, where new WtE capacities are proposed in localities with sufficient waste availability. Potential interaction with other projects operated in unified waste market is taken into consideration. In addition, it is also possible to determine the financial attractiveness of intended sites for construction and to test the project‘s stability under inconvenient future conditions. Two practical examples were presented motivated by the current situation in the Czech Republic. The model is universal and may be modified depending on the assignment. Applications of this tool on the European level also seem promising. Future changes in waste flows between countries can be simulated to reach an optimized system, where all processing capacities, i.e. new and existing ones, are effectively utilized.

6. Acknowledgement

The authors gratefully acknowledge financial support provided by Technology Agency of the Czech Republic within the research project No. TE02000236 *Waste-to-Energy (WtE) Competence Centre*. At the same time, financial support provided by the Ministry of Education, Youth and Sports within the research project CZ.1.05/2.1.00/01.0002 *NETME Centre* New Technologies for Mechanical Engineering and, in the follow-up sustainability stage, supported through NETME CENTRE PLUS (LO1202) is acknowledged

7. References

[1] Ecoprog GmbH. Waste to Energy - The World Market for Waste Incineration Plants 2013/2014, July 2013

[2] EEA European Environment Agency: Managing municipal solid waste — a review of achievements in 32 European countries, Report, February 2013, Luxembourg

[3] European Commission DG Env, Use of economic instruments and waste management performances – final report, April 2012

[4] Ghiani G. et al. Operations research in solid waste management: A survey of strategic and tactical issues. Computers & Operations Research, 44(2014)22–32

[5] Reimann D.O. CEWEP energy report III (Status 2007 - 2010) Results of specific data for energy, efficiency rates and coefficients, plant efficiency factors and NCV of 314 european waste-to-energy plants, Bamberg, Germany, 2013

[6] Roll H. und Chartschenko P. Marktumfeld für die Abfallverbrennung in Deustschland. In: Strategie plannung Umweltrecht, Band 8, TK Verlag Karl Thomé-Kozmiensky, Neuruppin 2014 (in german)

[7] Šomplák R., Pavlas M, Kropáč J., Putna O. Procházka V. Logistic Model Based Tool for Policy-Making towards Sustainable Waste Management. Clean Technologies and Environmental Policy. 2014 (DOI 10.1007/s10098-014-0744-5, in pres)

[8] Stäblein C. and Lidmila M., Quo vadis – Abfallströme in Europa, In: Strategie plannung Umweltrecht, Band 8, TK Verlag Karl Thomé-Kozmiensky, Neuruppin 2014 (in german)

[9] Thiel S. Production and Utilisation of Solid Recovered Fuels in Germany, In: Waste management, Volume 3 Recycling and Recovery, TK Verlag Karl Thomé-Kozmiensky, Neuruppin, 2012

[10] Van de Wiel H., Incineration tax unpopular with European Industry. Reward good behaviour, punish bad behaviour. Afvalforum. September 2010, 6 – 9