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Towards Future Electricity Networks

Project Phase 2

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Zusammenfassung

This is the first Annual Report within the second phase of the project "Towards Future Electricity Networks" which is ongoing at the Power Systems Laboratory of ETH Zurich. In 2009 the following tasks have been in focus:

- Implementation of the sustainability optimal power flow (SOPF), for the evaluation of future transmission investment plans.
- Reduction of the European transmission network based on publicly available data.
- Environmental policy issues internalizing the external costs of power production.
- Time-dependent inputs of the model considering future power plants installations.
- Strengthening of the collaboration with Chalmers University of technology in Sweden.

The predefined goals have been reached so far, followed by 2 published papers in IEEE conferences and one more submitted paper together with the research group from Chalmers.

Projektziele

The motivation arises from the worldwide reconstruction of the electric power systems that is taking place under increasing end-user energy demand, environmental changes and active trading markets. The realization of the common market in Europe, as well as power supply improvements in other regions, is not possible without investments in the transmission sector. These investments can be either in new transmission lines or in line capability upgrades using new technologies, e.g. HVDC or FACTS devices. This means that the planning of electric power systems and transmission system cannot remain the same as up to now. The generation sector and the energy balance is an important part of the electric power systems planning, but the present requirements in Europe and other places in the world call for new methods and tools to analyze the development of the electricity system, including the transmission systems [1].

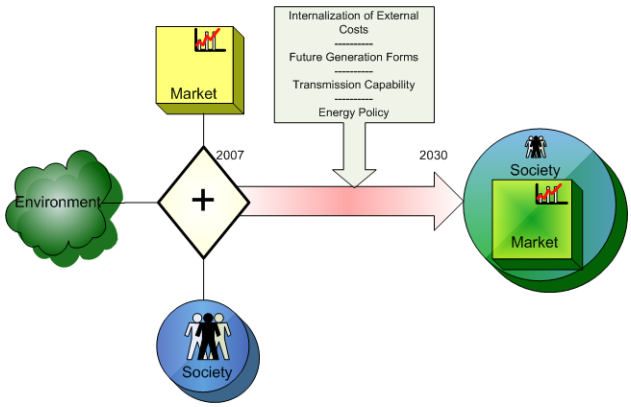

Figure 1 Combination of environmental aspects, market issues and societal standards together with external costs of power production, energy policies and future generation and transmission capability on the way to a sustainable future power system. (see project phase 1)

The overall goal of this project is to develop an analysis and planning tool that takes into account economic, environmental and social considerations. Furthermore, based on studies and investigations using that tool, sustainable transmission investment plans supporting the transition to future grids should be developed. More explicitly the tool should, in addition to standard power planning tools, embrace

• Future power plants
• Power transmission system
• Indirect costs caused by the electric power system
• Environmental and societal standards

From a Swiss perspective this project is particularly of interest because of the often exhausted transmission capability at the borders, as well as the well known “Stromlücke”.

Furthermore, pump storage hydro power plants will in the future play an important role as balancing and regulating power, and if this should be used to balance e.g. wind generation in Germany, adequate transmission capacity should be available. With the tools and models to be developed all these issues can be further studied and analyzed.
The project is cooperation between ETH Zurich and Chalmers University of Technology, Sweden.

The project targets of 2009 are described below:

1. Sustainability based optimal power flow (SOPF) improvement, inclusion of investment economics and time dependent multi-objective optimization.
2. Reduced European model depending on collected data, reduction techniques and approximated cost curves.
3. Consideration of future power plants according to Chalmers data.
4. Publication of a common paper with Chalmers.

Durchgeführte Arbeiten und erreichte Ergebnisse

During 2009, a lot of emphasis has been given to the internalization of external costs of power production and its impact on the identification of investment plans. As an accurate value for external costs cannot be easily estimated, their consideration represents mainly the different environmental policy strategies that can be applied in different countries and how a certain policy can affect the transmission planning decisions.
Additionally the internalization of external costs helps along the identification of sustainable plans, providing correct price signals based on nodal price modelling [2].

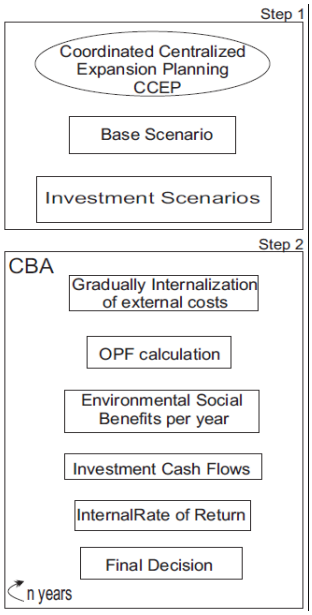

Figure 2 Cost-benefit analysis

The aggregated benefit of the internalization is usually higher than the social welfare deficit, depending on the energy mix, and can be further used in order to reinforce the existing electricity network, financing ”green” investments. The idea is the coordination of generation, transmission and policy planning, and their interaction, towards a common electricity market. A cost benefit analysis (CBA) (see fig. 2) has been implemented in order to support the final decision taken.
The proposed cost benefit analysis process is able to provide information about the profitability of future coordinated projects in respect to environmental and social issues, with the aim of a gradually internalization of external costs. Summarizing, using an aggregated methodology that allows the combination of generation, transmission and policy planning, one can argue that the total profits of internalization of external costs in power production can finance coordinated investment plans, even of a very large scale, where the investment costs are extremely high [3].
Several scenarios, considering demand changes, power plants installations and investments in transmission are implemented by means of a European ”copperplate” model.

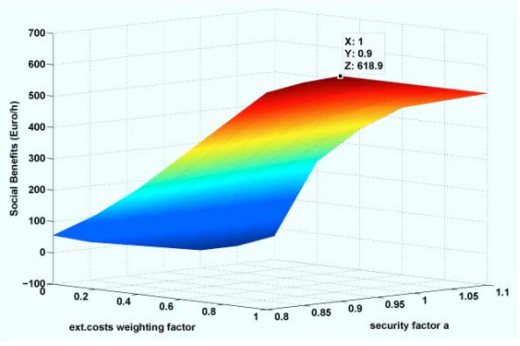

Figure 3 Trade-off curve social benefits after the generation expansion

The sustainability based optimal power flow (SOPF) has also been introduced. It is a multi-objective expansion planning tool in order to support and facilitate the characterization of a transmission or generation investment as beneficial or not. The tool is able to provide information for deci-

sion analysis based on economic, environmental and societal criteria, in terms of security of supply, using trade-off curves and weighted internalized external costs. The results have described the impact of policy strategy and transmission network utilization on the social welfare and the social benefits of externalities internalization. An example is given in figure 3 where it is depicted how the social benefits of the system change installing more “green” generation capacity. The optimum reflects to the highest internalization level of external costs, but the installation of more “green” power allows 10% higher utilization of the transmission network capacity than in the base case. Fully internalization, fully utilization or both does not always lead to an optimum point, which means that a compromise is needed from the decision maker.

Furthermore, the change in system prices and system losses has been studied as well. It has been shown that the level of internalization is a key issue in order to compensate the negative environmental impact of high utilization of transmission lines. In case that green investments are promoted, it may happen that the best solution regarding social benefits doesn’t reflect always to the highest system price or to the highest system losses [4].

Nationale Zusammenarbeit

The project interacts with the „IRENE-40“ project, which is an FP7 EU project, discussing common problems and methods for reduction techniques of the European electricity network, as well as how to represent the marginal cost curves. There are some ideas for closer collaboration, e.g. on the development of the reduced model, however not definitely assigned.

Internationale Zusammenarbeit

The last year three meetings have been held with the group of Prof. Lina Bertling and Filip Johnsson, one at Chalmers and two at ETH Zürich in order to deepen our collaboration. Plans for future work have been defined and a common paper has been also submitted to the General meeting of IEEE PES 2010 [5]. The paper deals with the interaction between new installed production capacity and transmission investments, as a result of a cooperative work between the ”Pathways to Sustainable European Energy Systems” project at Chalmers university of technology and the ”Towards future electricity networks” project.
The goal of the cooperation is to identify common investment strategies for supporting the power plants of the future with appropriate electricity network plans building a sustainable power system.

Bewertung 2009 und Ausblick 2010

The targets of 2009 have been reached so far. The sustainability based optimal power flow has been presented in Powertech ’09 IEEE conference, however additional features will be implemented in 2010 as well. The approach of the cost-benefit analysis allows the consideration of investment economics and provides adequate information of the profitability of the new transmission plans. Furthermore, the collaboration with Chalmers was very successful and fruitful and there are already scheduled tasks for the future.

Regarding the reduced European model, some methods have been implemented, without giving appropriate equivalent models for the purpose of the project though. Due to limited data availability of the completed UCTE network, a simplified European aggregated model of 20 buses has been used so far, and new approaches are going to be implemented in the coming months.

The targets for 2010 are following:

- Implementation of the UCTE optimal power flow model and investment proposals
- Studies about adequate Swiss cross-border capacities and transmission bottlenecks within the neighbouring countries.
- Case studies based on the Swiss perspective in order to analyze the position of Switzerland in the future electricity network and to examine its profitability besides sustainability.
- Publication of one more paper with Chalmers
- Final report of the project and dissertation delivery

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