

Regional Optimizer (RegiOpt) – Sustainable energy technology network solutions for regions

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Abstract

Developing energy strategies for the future is an important strategic task for regions and municipalities. Renewable based technologies and decentralized energy supply based on regional resources have the potential to locally and regionally increase added value, provide new jobs, decrease the dependency on limited fossil resources as well as on external energy providers and may have a positive impact on ecological stability.

Regional Optimizer (RegiOpt) software tool is based on the concept of Process Network Synthesis (PNS) (Friedler et. al, 1995 and Halasz et. al, 2005) and of the Sustainable Process Index (SPI) (Kotscheck et. al., 1996 and Sandholzer et. al., 2005). Both methodologies are combined in RegiOpt to enable the user to create economically optimal sustainable energy technology networks and at the same time evaluate them with respect to environmental sustainability.

Inputs to the software are (renewable) resources (e.g. amount of crops available for energetic use, biowaste, waste heat, etc.) and regional energy demand profiles. Both resource provision and energy demand can be provided in time dependent form. On top of that the user may supply contextual information like costs and prices of particular resources and services.

Result of the calculation with RegiOpt is the economically optimized technology network that fulfills the energy needs defined by the user and renders the highest regional added value. RegiOpt also provides the ecological footprint according to the SPI methodology. The user is able to calculate different scenarios based on different input data. RegiOpt software tool will be provided in two versions. Web based “Conceptual Planner” as a simple analysis for regional stakeholders and an “Advanced Designer” for a more detailed technology network scenario generation meant for expert use.

Keywords: Process Network Synthesis, PNS, Sustainable Process Index, SPI, Regions, energy production, electricity, heat, ecological footprint

1. Introduction

Local and regional stakeholders are increasingly interested in energy supply based on regionally available resources. Utilizing these resources increases the local or regional added value reduces economic dependencies and may also reduce ecological pressures,

in particular green house gas emissions. Local economic is supported and new jobs are provided.

Every region however differs in terms of their available resources as well as their energy demand and market opportunities. Therefore RegiOpt. should help local stakeholders and decision makers to generate feasible future scenarios for their region. The user of RegiOpt gets an optimal renewable resource based technology network in accordance with the economical context of the region that is evaluated with the ecological footprint. By varying key parameters (e.g. prices for crops or conventional energy sources, availability of renewable resources and prices for energy services and products) a user will be able to generate scenarios that render a comprehensive picture of feasible development pathways for the region in question.

2. RegiOpt – A software tool for regions

RegiOpt combines two well established methodologies for process network analysis and evaluation of ecological sustainability. Process Network Synthesis (PNS) [Z,Y] is used to generate optimized technology networks using of a predefined set of available technologies provided within the software. In this set only technologies are considered that have proven their feasibility and that have been implemented at least on pilot scale. The PNS routine will select suitable technologies for any given region depending on availability of resources and the structure of the energy demand. Economic optimization will then render the most optimal technology network that links available resources with regional demand (possibly including necessary imports and indicating surplus production). The user may define restrictions for the scenarios (e.g. demand that have to be strictly met, upper limits for market capacity to absorb certain products, etc.) as well as time profiles for demand and resource provision (at least when applying the “Advanced Designer”).

This optimized technology network is evaluated in terms of environmental pressures with the Sustainable Process Index (SPI) [X,W] method. The final result provides a potential economic output (annual profit) and an ecological footprint for any given scenario.

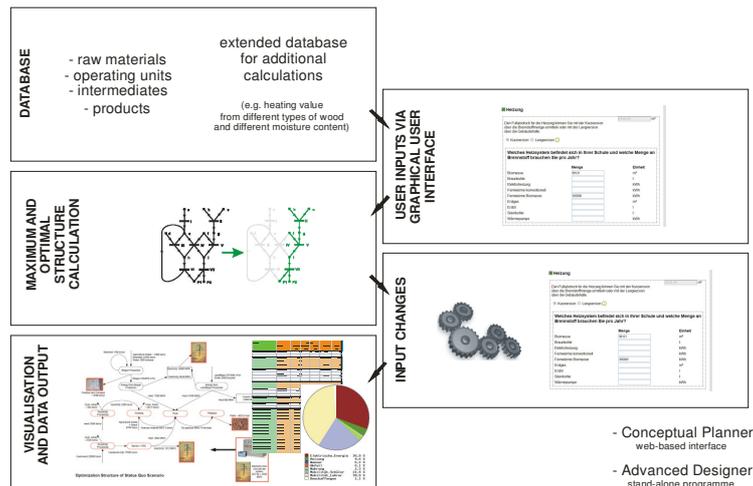


Figure 1: RegiOpt Macrostructure

The result is based on a predefined renewable energy technology list which is stored in a background database and will be up-dated in terms of performance and costs of technologies in regular intervals. Combined with contextual inputs given by the user following an input protocol the calculation is performed according to the architecture depicted in Figure 1.

Two different versions of RegiOpt will be available: a web based “Conceptual Planner” (CP) and a stand-alone program called “Advanced Designer” (AD). Both are using the same database but differ in graphical user interface. Conceptual Planner is meant for regional stakeholders and decision makers and will provide them with the ability to generate an optimized technology network based on a simple input protocol requiring non-expert knowledge on a website. AD version is dedicated for expert use only and will require more specific and detailed information of the region and will provide encompassing information taking spatial resource distribution and temporal profiles for resource provision and demand into consideration. AD and CP however are based on the same RegiOpt - Solver.

2.1. Database

A major feature of RegiOpt is an encompassing database. It includes

- raw materials (renewable resources)
- intermediates (e.g. biogas)
- products (e.g. electricity)
- operating units (technologies)

and provides basic data for each item like yields for different renewable resources, composition of materials and current prices for resources, products and energy services as well as mass and energy balances for conversion technologies and basic economic data like operating costs and investment costs (in most cases for different scales of any given technology). This list is compiled from real world projects as well as from literature data and information from technology providers. This list represent a “maximum structure” with regard to process synthesis.

For CP the database (and hence the maximum structure) is fixed and cannot be modified. AD provides the user however with the possibility to add, deleted or modify existing datasets.

2.2. Conceptual Planner CP

The CP operates as a webpage and enables users to calculate an optimized technology network for their regions based on non-expert knowledge. The user follows an input protocol that shortens the list of technologies in the maximum structure based on regionally available resources and demands. The user is asked for available areas in different qualities (crop land, forests, grassland and possible areas for solar energy technologies).

Figure 2 illustrates how the amount of available resources is deduced from this input. Forest areas are interesting for energy wood that in turn is a possible input for different technologies (e.g. biomass burner, wood pellets production, biomass based combined heat and power (CHP) plants, etc.). The user has to define how much wood is already used (e.g. timber, wood products like furniture, energy wood for existing energy supply). Any excess biomass it will be used for as a resource for the generation of the

optimised technology network generated by RegiOpt. Crop land can be used for energy crops where RegiOpt adapts the set of possible crops to the climatic zone where the region is located. Acreage necessary for food and fodder production is subtracted and the rest can be used for energy crops with RegiOpt taking care of possible competition between different crop productions.

Grassland can be used to provide input for a number of technologies, e.g. biogas production. Again acreage used by ruminants will be subtracted and the rest can be used for providing raw material to the technology network.

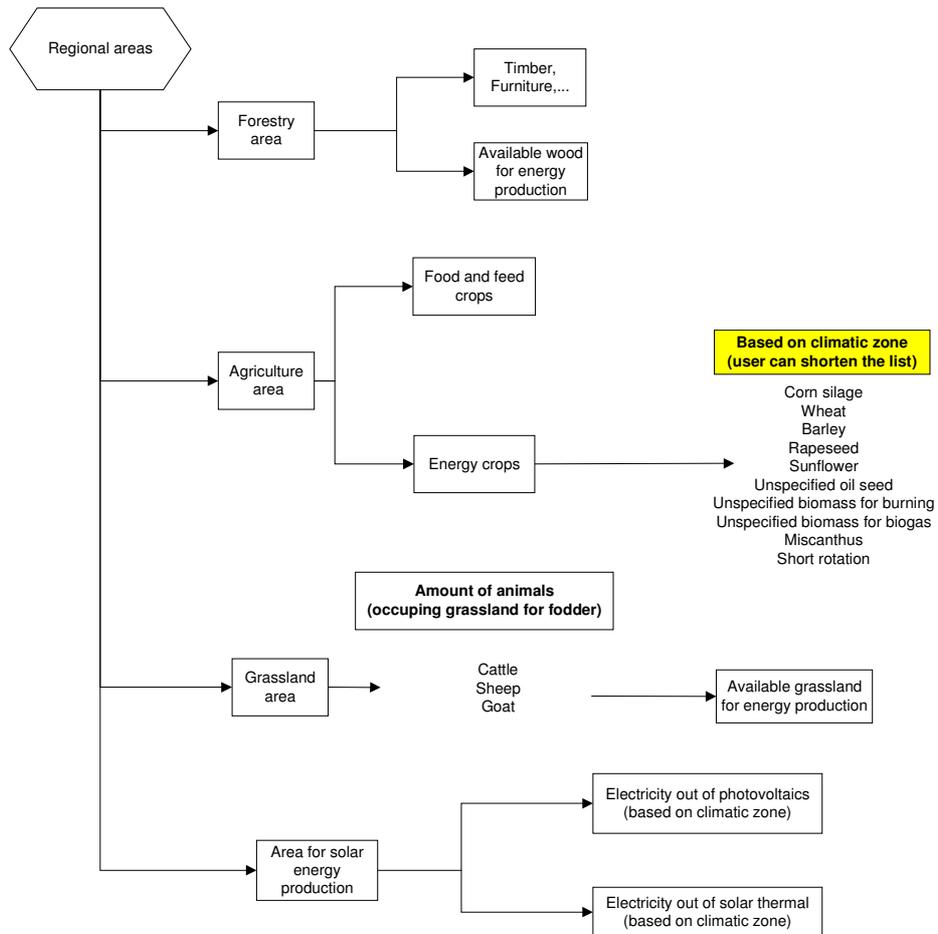


Figure 2: RegiOpt – CP; Area conversion methodology

The focus of the CP lies on providing a “quick and reliable” first analysis of the potential for a given region. It should be seen as a valuable starting point for a planning process, providing local and regional stakeholders with a solid base for discourse..

2.3. Advanced Designer AD

Detailed regional planning for future pathways towards sustainable energy systems will be supported by the AD. Although the basic database and the RegiOpt – Solver is the same for CP and AD, AD will provide expert user with a broad possibility to contextualize the data and to include time profiles as well as a first order spatial differentiation of demand and resource provision within a region. Results from the AD will therefore provide the user with additional information, in particular about the location, size and operational characteristics of the technologies involved in the regional sustainable energy system.

2.4. Results

RegiOpt-Solver (both for CP and AD) generates an optimal technology network for a sustainable energy system for any given region, using local and regional resources and fulfilling local and regional demand. The result for a given scenario based on the contextual data provided by the user will show the annual profit for the whole network as well as necessary investment costs and operating costs for the technologies involved. In addition an ecological footprint is calculated for the scenario, providing insight into possible ecological risks and highlighting benefits. Results can be stored for comparison with further scenarios, using different contextual frameworks.

2.5. Conclusion/Outlook

RegiOpt will be a powerful tool to support local and regional decision makers as well as energy experts in planning of sustainable local and regional energy systems. The web based CP part of RegiOpt will give non-expert local and regional stakeholders with a solid base for their initial discourse by providing them with a comprehensive first analysis of their chances for using local resources and meeting local demand. It also provides them with a versatile tool to develop a feasible vision for their energy future and with information about necessary co-operation between different sectors and stakeholders.

The AD part of the software will enable experts to build on the energy vision defined by non-expert stakeholders and optimize the technology network to accommodate time profiles for resource provision and demand as well as to decide about the best spatial distribution of the elements of the technology network.

References

- Z. Friedler F, Varga JB, Fan LT. Decision-mapping: a tool for consistent and complete decisions in process synthesis. *Chemical Engineering Science* 1995;50:1755-1768
- Y. Halasz L, Povoden G, Narodoslowsky M. Sustainable processes synthesis for renewable resources. *Resources, Conservation and Recycling* 2005; 44:293-307
- X. Sandholzer, D.; Niederl, A.; Narodoslowsky, M., 2005. SPionExcel – fast and easy calculation of the Sustainable Process Index via computer *Chemical Engineering Transactions* 7 (2) 443-446
- W. Krotscheck, C., M. Narodoslowsky (1996). The Sustainable Process Index - A new Dimension in Ecological Evaluation. *Ecological Engineering* 6/4 (1996) pp. 241-258