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Foundations for an IT-based Solution Manager for the Planning of Bio Energy Networks

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Abstract

The recent and mid-term development in the national and international energy production was influenced toward a more environmental friendly as well as sustainable way of energy generation. Beside the development for distributed singular electricity generation systems, there is an ongoing process of professionalization and wider distribution of bio energy throughout the whole energy sector. As the growing or gathering of bio mass as well as the methods of distribution and usage of the energy products (gas, heat, and electricity) are very manifold, early and comprehensive support in diverse decision processes regarding the Bio Energy Networks is needed. Methodical support is needed in different phases connected to these networks: Planning, Rating, Evaluation, Comparison and Communication of different alternatives (PRECC-Principle). To enable stakeholders of bio energy networks in applying the PRECC-Principle, IT-based support with a modular software framework is needed. This concept for a framework can be derived to further application scenarios, reaching from other alternative energy sectors to further distribution of bio energy.

1. Introduction

The energy market is undergoing substantial changes. Especially in Germany, this development can be seen in terms of the generation, the distribution, and finally the usage of energy. These areas are undergoing a transformation to be more sustainable and especially environmental friendly as a long-term goal. This transformation in Germany is mainly due to the recent decision to move away from nuclear power, which in term has its cause in the 2011 catastrophes in Fukushima, Japan. The transition to forms of sustainable energy generation, distribution, and usage of energy has additionally special incentives in Germany driven by regulations ensuring guaranteed stable energy prices that for vendors of renewable energies[2].

As different scenarios for the creation or modification of bio energy networks can be thought of, a structured methodology is needed in order to have a holistic toolset throughout the planning of these networks.

In this paper, a generic methodology is presented and explained in detail. This methodology for the holistic and sustainable planning of generic projects will then be applied to the process of designing bioenergy networks. It is shown how it will be possible to provide an ICT supported planning tool for this use case and a small prototype is presented. This prototype is geared towards the possibility to provide eParticipation during the planning phase and thus shows how sustainability concerns can be integrated well into the decision making process as early as possible.

2. PRECC – a theoretical approach for integrated decision support

During the scientific work in several research projects it was discovered, that no generic methodology for planning process exists. Furthermore, the concept of having different stakeholder groups participating during the planning is mostly not taken into account. But especially when it comes to projects that are done by the

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government, recent events like the highly controversial plan to build a new main train station in Stuttgart (the so called "Stuttgart 21" project) have shown, that traditional means of stakeholder communication and participation are likely to fail.
When it comes to the planning of bioenergy networks, stakeholder integration is also very important. Even if the project participants are partially private entities, many heterogenic stakeholders have to be considered. The production of biomass is mostly a local or regional process, so it is desired to include as much stakeholders as possible. As for example, the usage of biomass to generate energy using fermentation or combustion can be quite disturbing for neighbors or whole villages. This is a typical example where eParticipation provides an opportunity to integrate all stakeholders during the planning phase and provide them with the ability to help the decision making process (e.g. in Reddick, 2010 or Giesen & Suepke, 2011). After decision making it is then easier to provide the public with a reasonable planning decision. This decision making process can be supported in an ICT solution by the inclusion of mathematical decision aid methodologies like for example PROMETHEE and GAIA (s.f. in Brans & Mareschal 2005).
The proposed principle is divided in five main phases namely:

- **Planning** of the project including different variations and alternatives,
- **Rating** using indicator sets and values,
- **Evaluation** of indicators for all variations using e.g. computer science,
- **Comparison** of the evaluation and making a decision and
- **Communication** of the results.

These five different phases of the principle are done sequentially and can furthermore be repeated in an iterative manner as needed. The overall process concept is shown in figure 1 using the iterative approach.

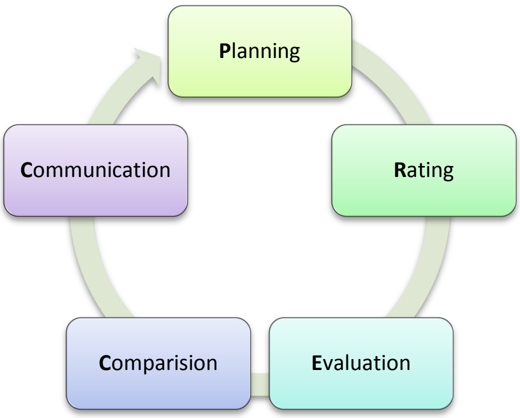

Figure 1: Circle of PRECC

The details for each phase of the PRECC principle are explained in greater detail in the following subsections.

2.1 Planning phase

The planning is the initial phase of the PRECC principle and builds the basic foundation of all following phases. In this phase, the desired project has to be defined in a clear and distinguished way so it can be modeled using appropriate software supported tools. For the mentioned example of a bioenergy network, this can be done by pointing out the different stages (materials supply, logistics, energy production, grid distribution, and energy usage) of a bioenergy supply chain and detailing these in greater detail. This created model has to be as detailed as needed, so the different aspects of a project can be rated. The PRECC principle does not endorse a specific model as long as it is well structured and its content can be made clearly measurable using indicators.

A crucial part of the planning phase is furthermore the creation of different alternatives and scenarios, which will later be used for the decision making process. When planning the creation of a power plant its size could be one possible scenario parameter that has to be modeled appropriately. Additionally it is a good idea to provide a “no change at all” scenario so the effects of not realizing a project can be explored and taken into account as well. As all alternatives should be comparable for later phases, the selected indicators must be applied for all viewed scenarios.

2.2 Rating phase

After the base model and its associated alternatives have been developed, it is needed to define and specify appropriate indicators to each detail of the model that may be relevant to choose a variant of the desired project. The nature and theoretical background of the underlying indicators can be chosen freely so it is also possible to derive them using an inter-organizational or community based approach (s.f. Meyerholt et al. 2010), but for most decision support methods they need to fulfill some criteria (s.f. in Brans & Mareschal 2005):

- They must be ordinal so that different variations of the same base indicator can be compared.
- They must provide a minimize/maximize attribute so the decision support method has information how to optimize.
- A weight for the indicator has to be specified. This weighting is a rather crucial point, as it is needed to have a clue on the prioritization of different indicators.

Especially in the rating phase of the PRECC principle it is possible for project planners to include the different stakeholders in the decision making process of choosing the optimal project scenario to be realized. This can be accomplished for example by assessing the weightings of the indicator set using questionnaires or general surveys. Therefore, the general importance of each indicator can be determined and taken into consideration.

2.3 Evaluation phase

After the modeled project scenarios have been modeled and rated in the first two phases of the PRECC principle, it is subsequently possible to evaluate each project scenario and thus providing a ranked order of these.

Different methods of ICT decision support systems exist and can be applied to accomplish the evaluation of all modeled scenarios. For the principle shown here and the proposed IT-based Solution Manager, the evaluation and the order of all scenarios will be determined using the PROMETHEE methods (s.f. in Brans & Mareschal 2005). PROMETHEE provides a multi-criteria decision support methodology that can be implemented rather easy and provides nevertheless very useful results.

Of course the automatically generated ranking and prioritization of the different variations provided by an IT-based solution (e.g. in Giesen et. al., 2010) can be enhanced or enriched by traditional means of decision making, common sense knowledge or general requirements and limitations.

2.4 Comparison phase

In this phase, the results of the previous evaluation phase will be compared with each other and a preliminary or final decision for one or more specific variations can be made. This phase will mainly be done by presenting the best fitting project variations to all involved decision makers and the accompanying discussions.

As the selected project variations will be based mainly on the given weightings of the underlying indicators, every stakeholder should find its preference taken into account. The result of this phase should be a final selection of the best fitting project variation.

2.5 Communication phase

In the final phase of the PRECC principle, the final decision will be presented and communicated to all involved stakeholders. In terms of eParticipation, this can be done using IT-based methods like a project homepage or by an appropriate representation in the IT-based solution manager itself. Even further it-based methods like a geographic information system (GIS) can be used to support the eParticipative processes (e.g. Loukis et al. 2010).

During the communication phase, the stakeholders should be given a sufficient time to study the results and to provide their feedback. This phase will also be affected by discussions as the result of the chosen project alternative.

Depending on the requirements of the project the PRECC principle offers the possibility to repeat all phases from the beginning, if it is necessary. This can be the result of the discussions in the communication phase, by changed requirements for the project, or changed indicator values.

3. Outlook

The future research regarding the PRECC principle will focus mainly on three directions:

- Improving the theoretical background of each phase of PRECC,
- designing and implementing of an IT-based prototype,
- and evaluating the concept using appropriate case studies.

Especially the design and implementation of the prototype is the next goal to strive for. Even if the theoretical background of the PRECC principle could be changed slightly, this would not affect major parts of a prototype if it is designed well. For this and other reasons, the following manifold requirements for the IT-based solution manager have been defined:

- Affordability
- Scalability
- Maintainability
- Modularity
- Extensibility

These requirements will be fulfilled by following a component-based approach based on web services during the design and the implementation of the prototype. The usability of this approach has been proven for example in (Meyerholt et al. 2011). This allows to reuse existing components and to reduce the risks of having to redesign large parts of the prototype if the theoretical foundation of the PRECC principle changes. Furthermore, the requirements of having a maintainable, modular and extensible system are targeted using a component-based approach. Additionally it is possible to reuse many existing open source frameworks and components to reduce the time needed for the implementation of the IT-based solution manager.

The scalability requirement poses a unique opportunity to leverage modern cloud based infrastructure and so it is planned to develop the whole system as distributed as possible so it can be deployed on one or more servers. This will be done using an open source cloud infrastructure stack like OpenStack[3] or Eucalyptus[4], which are service compatible with commercial Infrastructure-as-a-Service (IaaS) providers like Amazon EC2[5]. In addition to the scalability of the software, it is furthermore possible to provide the IT-based solution manager using the Software-as-a-Service (SaaS) approach. The total cost of ownership can be minimized using the SaaS approach as well as additional processing power can be provided on demand.

4. Conclusions

In this research in progress paper, an innovative project planning approach has been presented in great detail. Additionally basic ideas for the realization of that concept using current trends in software development have been shown. The single phases of the principle have partly been evaluated and tested in theoretical and scientific environments, proving the general applicability of such an approach. The initial build-up of the five phases of the PRECC principle can be applied to many different scenarios. Current application fields are focused on sustainable and environmental research questions, but the application field is not limited to such a focus. With a more detailed and adapted model, the phases could be applied to many different processes, that depend or can profit of an integration of stakeholder interests and extensive communication of results.
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[4] See http://www.eucalyptus.com/
[5] See http://aws.amazon.com/ec2/