Integrated intelligence assessment for energy systems

[Simon Letzgus, Department of Energy Systems - TU Berlin, +49 (0)30 314 28684, simon.letzgus@tu-berlin.de]
[Christopher Koch, Department of Energy Systems - TU Berlin, +49 (0)30 314 28634, christopher.koch@tu-berlin.de]
[Prof. Dr. Georg Erdmann, Department of Energy Systems - TU Berlin, +49 (0)30 314 24656, georg.erdmann@tu-berlin.de]

Overview

Energy systems around the world are striving to become more environmental friendly and efficient. Conventional generation units are replaced by renewable, non-dispatchable and distributed generation (DG). Electricity markets and grids are being coupled to increase competitiveness and the security of supply. Essentially, these developments result in an increased system complexity. Consequently new tools for efficient and safe system operation are required. At the same time digitalisation has started to transform the world around us and the advances in information and communication technology (ICT) holds the potential to master many of the new challenges of the energy domain. The system wide implementation is currently being researched, for example by the German WindNODE-project [1].

Energy applications or sub-systems that make use of modern ICT are often labelled as ‘smart‘ or ‘intelligent‘ even though there is no coherent definition of energy system intelligence. Smart grids, for instance, optimise operational decisions based on their actual status and smart markets consider physical grid restricions when finding a market equlibrium [2], both enabeled by ICT. However, there is no method that allows the assessment of an energy system’s ‘intelligence’, a fact that is clearly linked to the missing definition of the term.

This poster will present a definition of energy system intelligence and moreover propose a metric for its evaluation. The approach will focus on measuring the contribution of ICT in four areas, which are considered key to solve the above described challenges: demand response integration, coupling of different energy sectors, optimization of grid operation and the coordination of decentral generation units. The method will reveal the added value of ICT for those fields of aplication and allow system comparisons.

Methods

Balanced scorecard (BSC) is a well established method for key performance indicator (KPI) development. It is a strategic planning and management tool used by organisations to capture their desired strategy and to include all drivers of performance [3]. Even though Kaplan and Norton [4] developed the BSC to evaluate business unit performance, the method can be transfered to other applications. It describes the derivation of concrete KPIs and measures coming from an overarching goal. Our approach contains the five steps, as displayed in Figure 1.

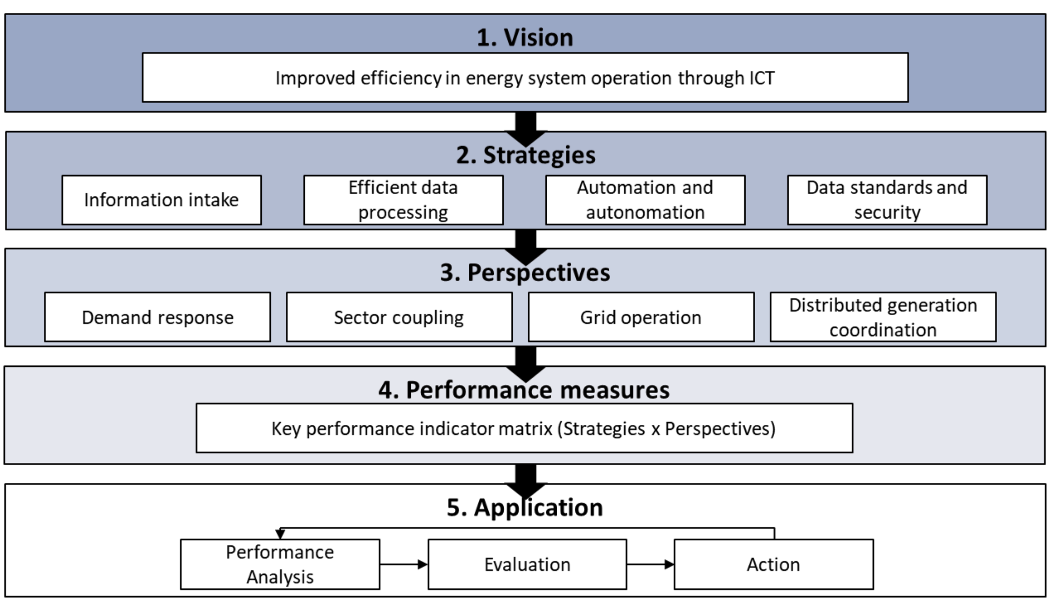

Figure 1: BSC to derive KPIs for an intelligent energy system.

The BSC development process starts with the definition of a *vision*. In our case, the vision suggests that ICT enables a more efficient system operation through its information processing capabilities. As a second step, the necessary *strategies* to implement the vision must be derived. There are four essential strategies for intelligent energy systems to achieve the presented vision: information intake, efficient data processing, automation and autonomation as well as data standards and security. By applying these strategies to different *perspectives*, namely the topics demand response, sector couptling, grid operation and the coordination of distributed generation units, the vision can be practically achieved. Next, *performance measures* are required to quantitatively and qualitatively describe to what extent the strategies contribute to the implementation of the vision through the different persepctives. Lastly, the application of the BSC must be conducted, starting with the performance analysis. That includes data collection and analysis to quantify the KPIs. The results can be evaluated afterwards to identify well developed and improvable areas and to derive actionable recommenadtions. In case respective measures are taken, they can be evaluated with the same scheme after implementation.

The main focus of this poster lays on the KPI definition. They have to fulfil several requirements, such as having a clear reference to the goals, being transparent and comprehensible and the availability of the relevant data [5]. Following these guidelines, KPIs are developed for each part of the value chain, indicating its level of intelligence.

Results

The BSC enables the derivation of KPIs to evaluate the intelligence of the considered perspectives. The currently ongoing development process is supported by stakeholders along the whole value chain within the scope of the WindNODE project [2]. The following overview shows a preliminary selection of KPIs for the perspective grid operation with respect to the corresponding strategies:

Information intake:	Share of nodes with phase measurement units (pmu); Share of consumers with smart meters, share of grid monitored by overhead line surveillance...
Efficient data processing:	Accuracy of renewable infeed and load prediction; Accuracy of simulation based grid state estimations with respect to time horizon; Accuracy of grid-boundary conditions (transit-flows/loop-flows); State estimation computing time in relation to system complexity…
Automation and autonomation:	Evaluation of data processing infrastructure (degree of automation); Share of automated processes in grid operation…
Data standards and security:	Availability of IT-security concepts, Standardized data exchange formats for anciliar services…

Conclusions

Measurement of energy system intelligence is a highly complex matter. A comprehensive methodology for such an evaluation has been missing so far. The presented approach will enable an analysis and benchmark of state-of-the-art energy systems and allow the conclusion to what extent ICT can and already does contribute to an efficient system operation in the areas of demand response, sector coupling, grid operation and distributed generation coordination. It will thereby help to determin a more effective digital agenda.

References

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