LINK - a model for an overall power system architecture

Albana Ilo
University of Technology of Vienna
Institute for Energy Systems and Electrical Drives

Working Group - System Architecture and Implementation Modelling
16-17 June 2016, Split, Croatia
Popular concepts in Smart Grids

Virtual Power Plants  Microgids

After more than 15 years research the question arises:

Are these concepts sufficiently broad to properly characterize the variety of the smart grid operation?
Popular concepts in Smart Grids

The adoption of microgrids as the paradigm for the massive integration of distributed generation will allow technical problems to be solved in a decentralized fashion, reducing the need for an extremely ramified and complex central coordination and facilitating the realization of the Smart Grid.”

What is a paradigm?

A paradigm is a symbolic model or diagram that makes it easier for us to understand the essential characteristics of a process.
A technical system consists of three major elements:

**LINK - Paradigm**

The LINK Paradigm


Working Group - System Architecture and Implementation Modelling
Architecture Elements

Link - Paradigm

Major architecture components: the Link

The Grid-Link is defined as a composition of a grid part, called Link_Grid, with the corresponding Secondary-Control and the Link_Interfaces.

- The Grid-Link refers to electrical equipment like lines/cables, transformers and reactive power devices, which are connected directly to each other by forming an electrical unity.
- The Grid-Link size is variable and is defined from the area, where the Link_Secondary-Control is set up.

Power system overview based on the “Energy Supply Chain Net” model: horizontal und vertical axis

Per definition the “Energy Supply Chain Net” is a set of automated power grids, intended for “Chain Links” or “Links”, which fit into one another to establish a flexible and reliable electrical connection. Each individual “Link” or a “Link”-bundle operates independently and have contractual arrangements with other relevant boundary “Links”, “Link”-bundles, and suppliers which inject directly to their own grid. Each “Link” or “Link”-bundle is communicatively coupled with the other relevant “Links” or “Link”-bundle’s via the usual communication instruments.

Holistic power market model
Flat business model of the electricity industry
Holistic model of the electrical industry
Harmonisation of power grid physics and market rules
Working Group - System Architecture and Implementation Modelling
Demand response process:
line overload on high voltage grid

**HV_Link**
One line is overloaded. It is required 2% and 6% demand reduction in points A<sup>H</sup> and B<sup>H</sup> respectively.

**MV_Link_1**
2% demand reduction can be reached by using CVR. No other actions are necessary.

**MV_Link_2**
Only 5.4% demand reduction can be reached by using CVR. Other actions are necessary.

The scheduled data exchange on:

a) centralized and b) decentralized architectures

Article 25
Scheduled data exchange between TSOs, DSOs and Significant Grid Users according to Article 1(5)(a) and Article 1(5)(d) connected to the Distribution Network

1. Each Significant Grid User which is a Power Generating Facility Owner according to the Article 1(5)(a) and Article 1(5)(d) and with Connection Point to the Distribution Network, shall provide its TSO and/or its DSO with its scheduled unavailability, Active Power restriction and its forecast scheduled Active Power output at the Connection Point. Organization of the data exchange shall be defined according to the key organisational requirements, roles and responsibilities established in Article 16(6) to Article 16(8).

2. Each Significant Grid User which is a Power Generating Facility Owner according to Article 1(5)(a) and Article 1(5)(d) shall provide to its TSO and/or its DSO any forecasted restriction in the Reactive Power control capability. Organization of the data exchange shall be defined according to the key organisational requirements, roles and responsibilities established in Article 16(6) to Article 16(8).

Source: Network Code on Operational Security, 24 September 2013, ENTSO-e homepage
The scheduled data exchange on:

a) centralized and  b) decentralized architectures

Number of exchanged schedules \( \Rightarrow 3 \cdot N \)

\( N \) – Number of Significant Grid Users (Power Generating Facility Owner)

MV-Grid-Link and Producer-Link, realized and operated in the framework of ZUQDE project

Reactive power and voltage control
MV-Grid-Link and Producer-Link, realized and operated in the framework of ZUQDE project

Reactive power and voltage control

\[ \cos(\phi) = \text{const.} \]
Conclusions

- The LINK paradigm helps to present the entire power grid and the costumer plants and to present all operation processes.

The new, LINK – based decentralised architecture for the power system operation:

- It is kept simple and distinct

- Provides cyber security and data privacy by minimizing the number of the exchanged data

- Facilitates all actual power system operation processes like load-generation balance, voltage assessment, outage managements, etc.

- Facilitates the involvement of demand response in the grid operation

- Fulfils the electricity market rules
Thank you for your attention

Albana Ilo
University of Technology of Vienna
Institute for Energy Systems and Electrical Drives
Telefon: +43 (0)1 58801 370114
Mail: albana.ilo@tuwien.ac.at

Working Group - System Architecture and Implementation Modelling
16- 17 June 2016, Split, Croatia