TECHNISCHE UNIVERSITÄT WIEN
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Minimization of exchanged data on the TSO-DSO cross border by application of a new operation architecture

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Content

ESEA
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- Problem statement
- Smart grid paradigm and architecture
- TSO – DSO cross border interface
- Impact on the “Network Code on Operational Security”
- Conclusions

Problem statement

The penetration of the new forms of energy, wind and photovoltaic, in form of small decentralized plants and slow storage development is challenging:

- the power system operation in transmission and distribution level
- the cyber attack risk on power grids is increasing drastically
- the data privacy is being seriously undermined

Virtual Power Plants

Microgids

…"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.**"…

Source: IEEE-PES Task Force on Microgrid Control, *"Trends in Microgrid Control"*, IEEE Transactions on smart grid, Vol. 5, No. 4, July 2014

Popular concepts in Smart Grids

. . . Each time we get into this logjam of too much trouble, too many problems, it is because the methods, that we are using are just like the ones we have used before. The next scheme, the new discovery, is going to be made in a completely different way. So, history does not help us much.

***Source**: RP. Feynman, "The character of physical law", New York: Modern Library, **1994**: p. 158..*

Richard Feynman

***Source**: Google*

Are these concepts

Virtual Power Plants **&** **Microgids**

sufficiently broad to properly characterize the variety of the smart grid operation?

***Source**: A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal* – Elsevier, Volume 131, **2016**, pp. 116-125.

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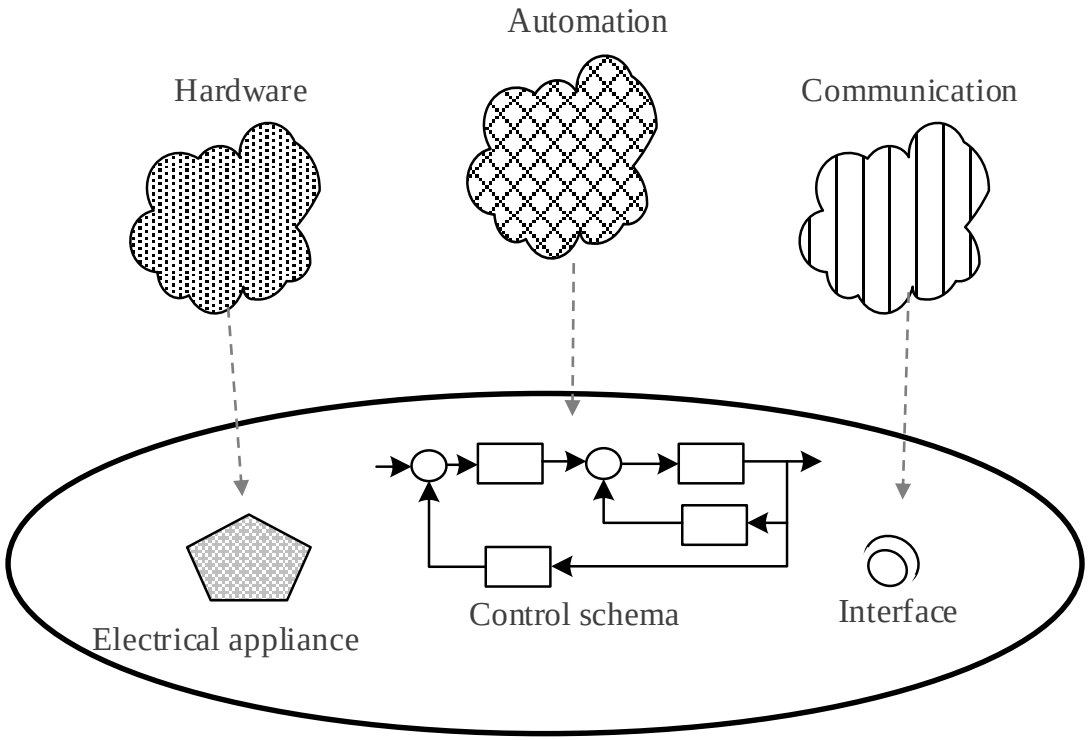
"*LINK*" – The Smart Grid Paradigm

A technical system consists of three major elements:

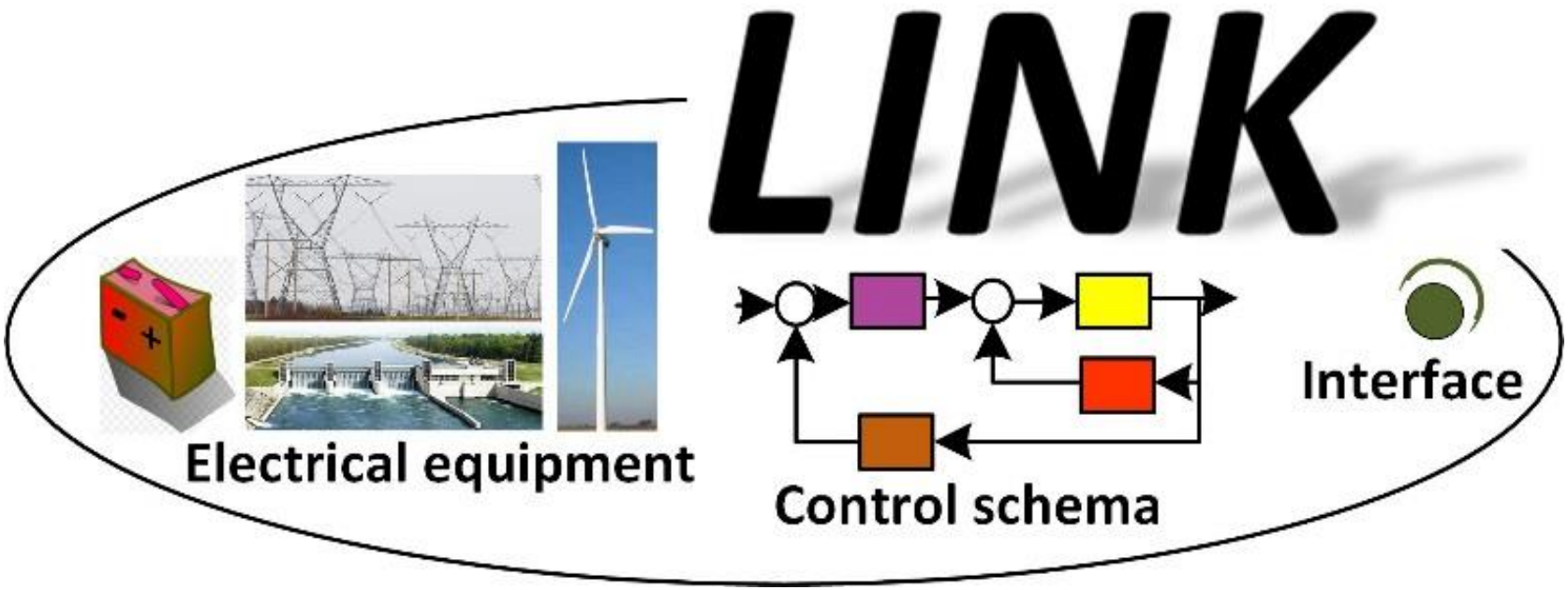


***LINK* - Paradigm**

***Source**: A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal* – Elsevier, Volume 131, **2016**, pp. 116-125.

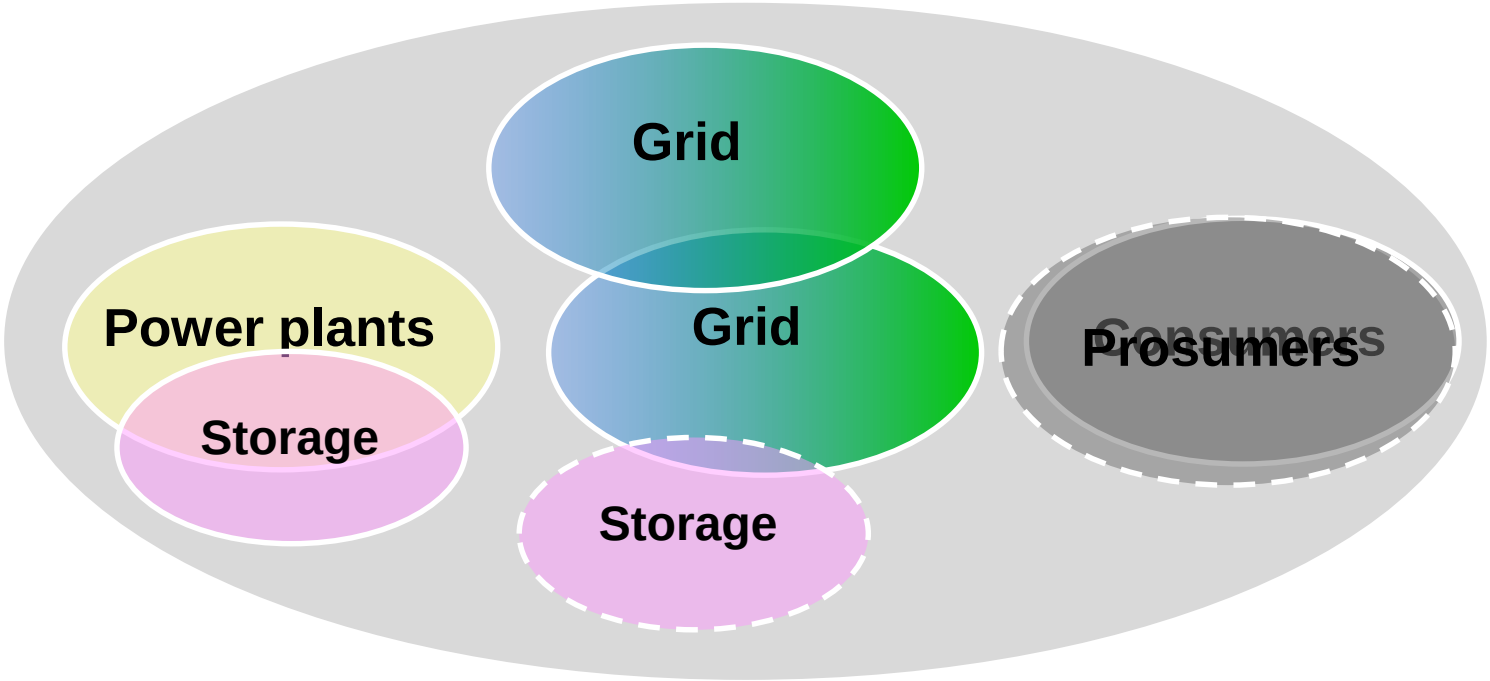
"Electrical chain link" or "*LINK*" – The Smart Grid Paradigm

LINK - paradigm is defined as a set of one or more electrical appliances – i.e. a grid part, a storage or a producer device -, the controlling scheme and the *LINK*-interface .



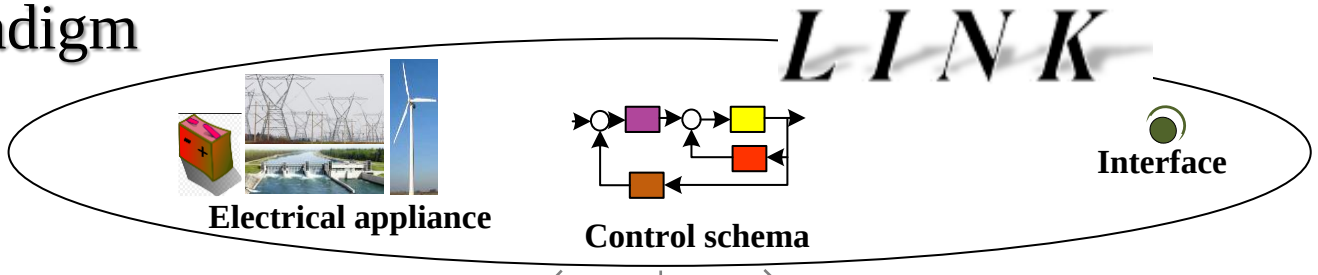
***Source**: A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal* – Elsevier, Volume 131, **2016**, pp. 116-125.

Main components of traditional power systems

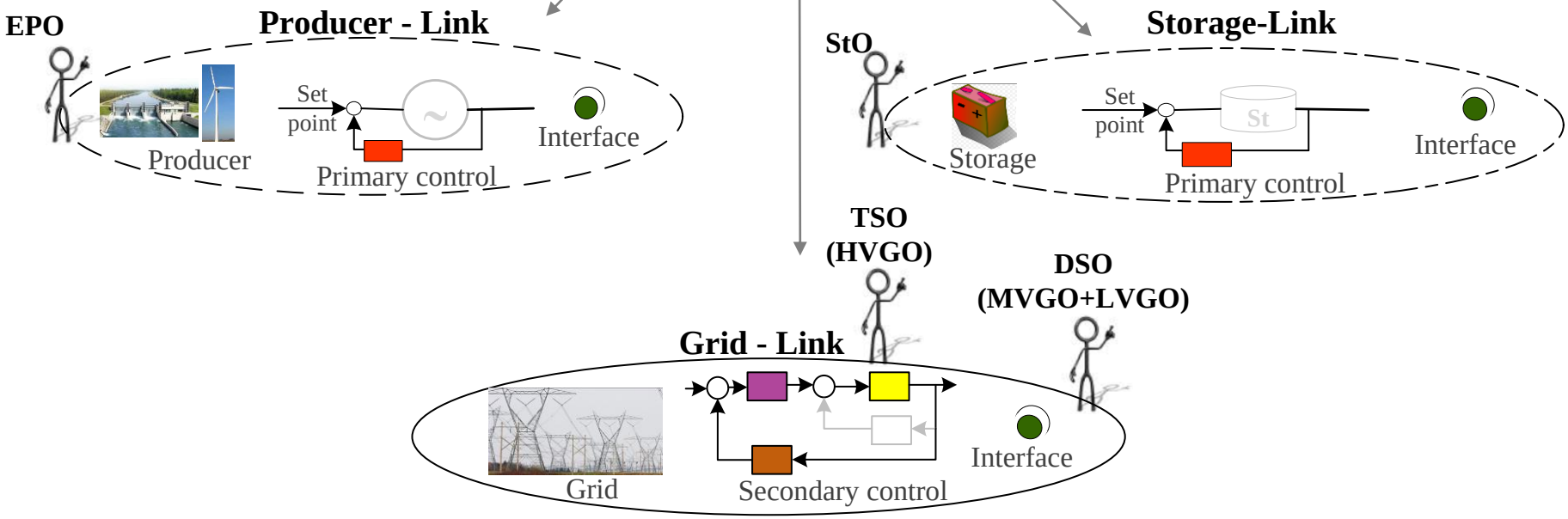


Architecture main elements

LINK - Paradigm



Architecture Elements



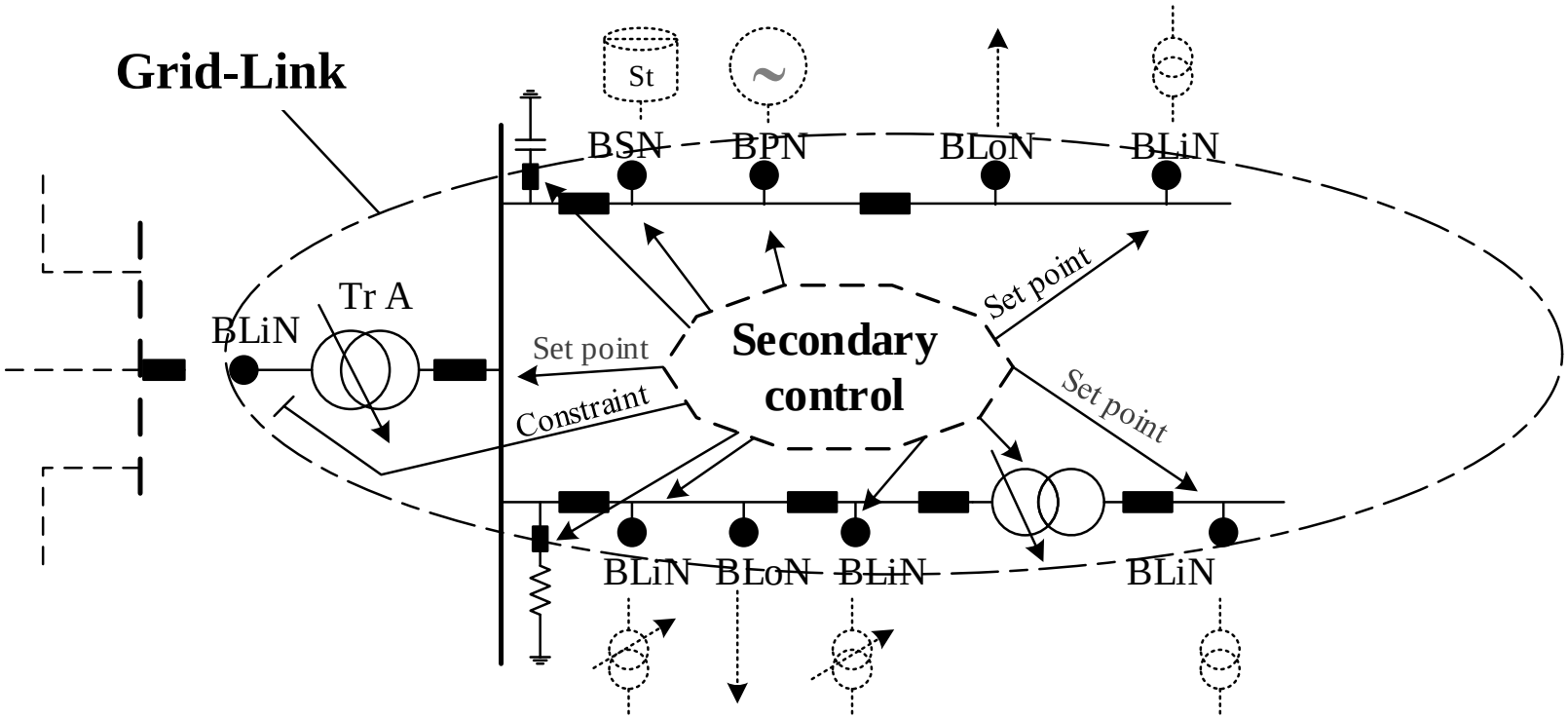
Source: *A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal* – Elsevier, Volume 131, **2016**, pp. 116-125.

Major architecture components:
the Grid-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.

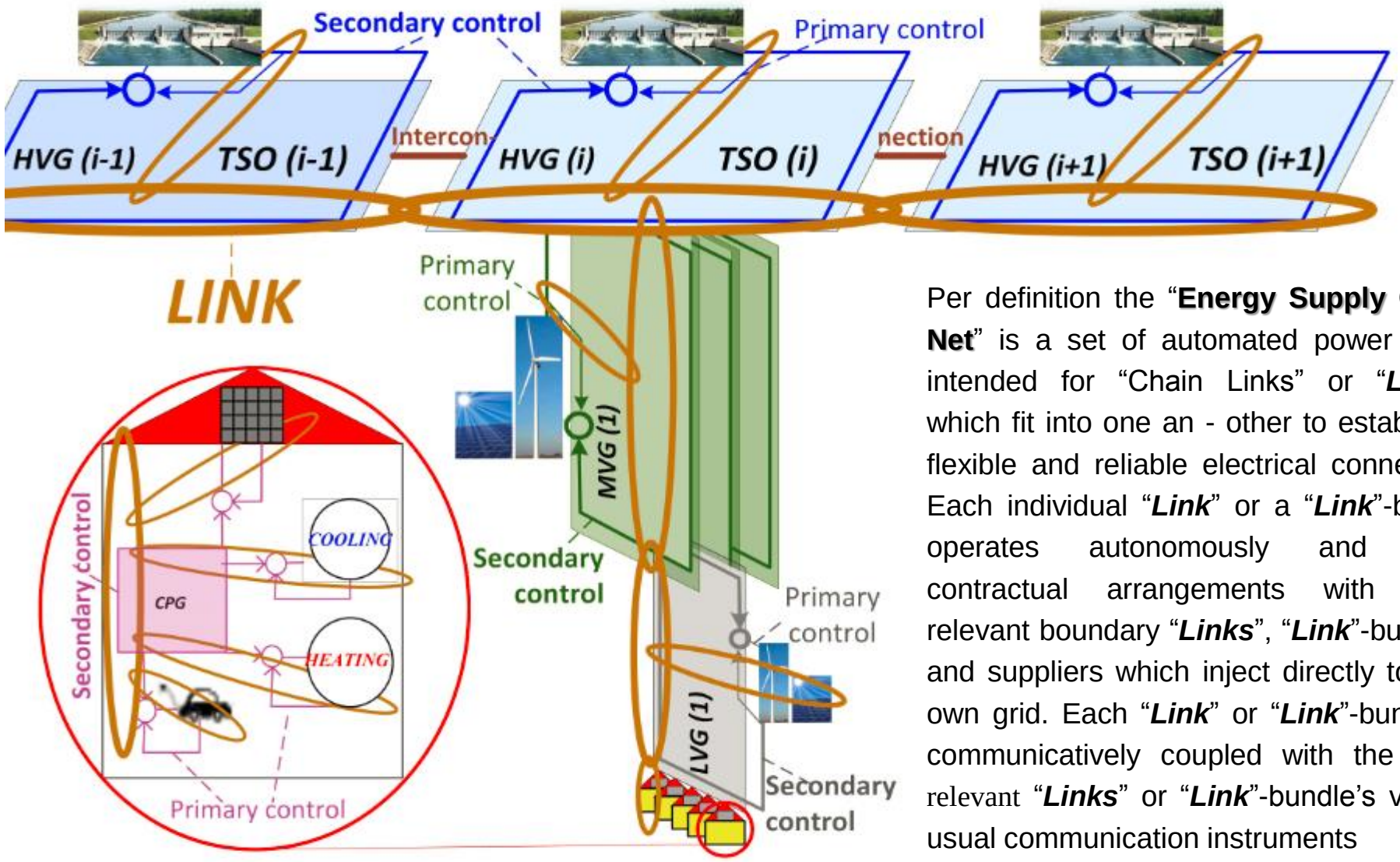
- The ***Link-Grid*** refers to electrical equipment like lines/cables, transformers and reactive power devices, which are connected directly to each other by forming an electrical unity.

- The ***Link-Grid size*** is variable and is defined from the area, where the Link_Secondary-Control is set up.



Source: *A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal* – Elsevier, Volume 131, **2016**, pp. 116-125.

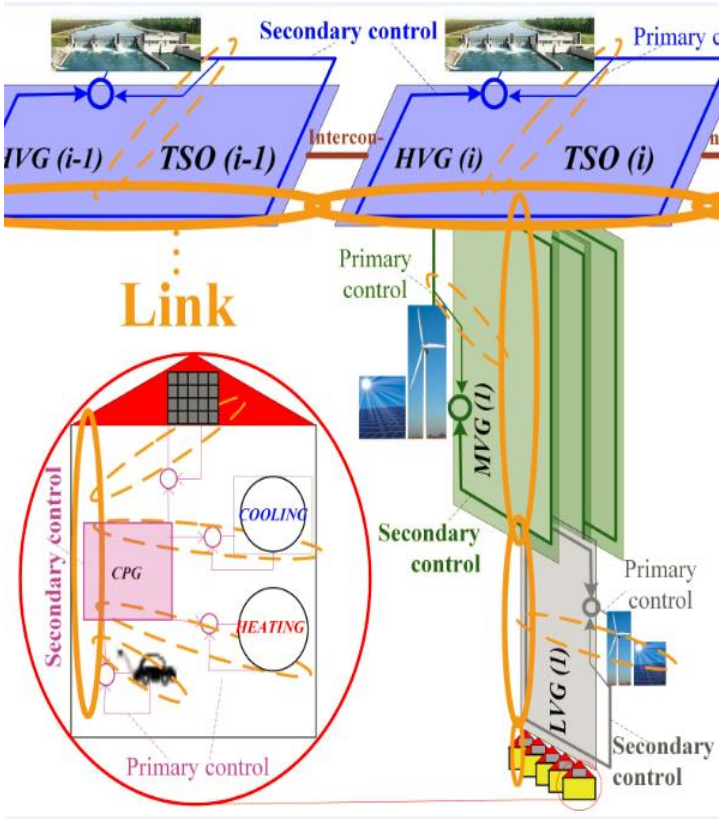
Power system overview based on the "Energy Supply Chain Net" model: horizontal und vertical axis



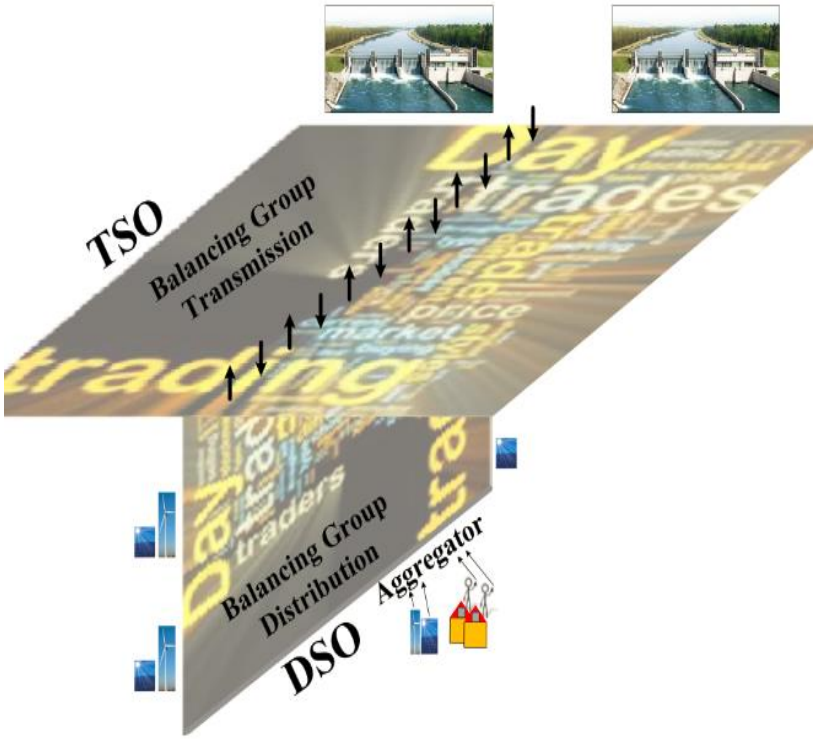
Per definition the "**Energy Supply Chain Net**" is a set of automated power grids, intended for "Chain Links" or "***Links***", which fit into one an - other to establish a flexible and reliable electrical connection. Each individual "***Link***" or a "***Link***"-bundle operates autonomously and have 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

Source: *A. Ilo "The Energy Supply Chain Net", Energy and Power Engineering, Volume 5 (5), July 2013.*

Holistic model of the electrical industry
Harmonisation of power grid physics and market rules

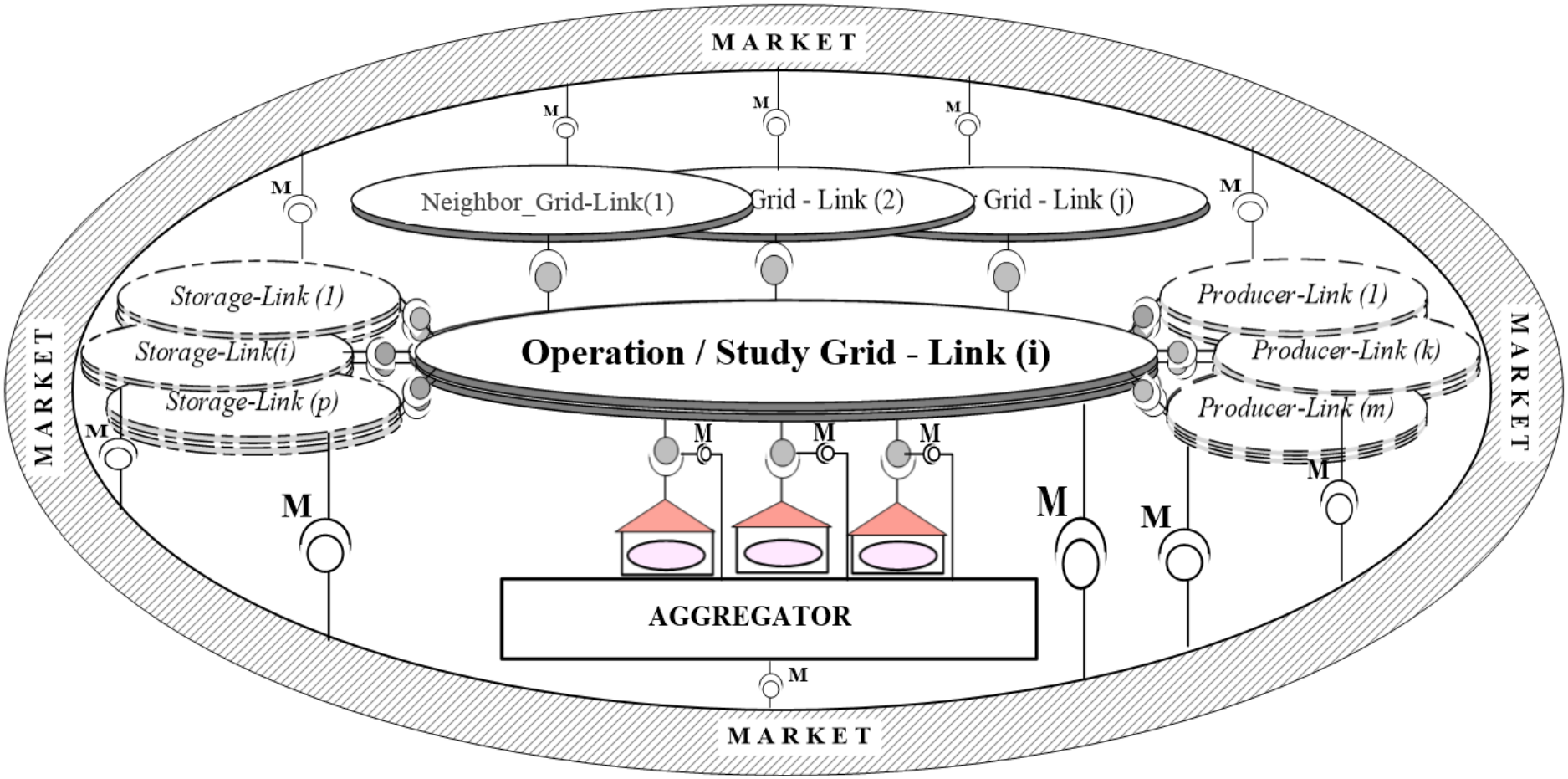


The "Energy Supply Chain Net" model



Holistic market model

Technical-functional architecture of smart power systems and electricity market



Content

Interface parameters on the TSO-DSO cross border

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- Monitoring	⇒	$f_{meas,}$ V_{meas}, $\delta_{meas,}$ P_{meas}, Q_{meas}
- Load-generation balance	⇒	$P_{des}^{nexthour} \pm \Delta P$ $P_{Schedule}^{dayahead} \pm \Delta P$
- Voltage assessment	⇒	$Q_{des}^{nexthour} \pm \Delta Q$ $Q_{Schedule}^{dayahead} \pm \Delta Q$
- Short circuit calculation	⇒	I_{equiv}, Z_{equiv}
- Static security (n-1)	⇒	I_{equiv}, Z_{equiv}
- Dynamic security (angle, voltage)	⇒	Static and dynamic load characteristic k_{PV}, k_{QV}, k_{Pf}, k_{Qf} … Dynamic equivalent Generator parameters like x_d, x'_d, …, T'_{d0}, … Equivalent governors, turbine parameters like K_1, T_{G1}, … Equivalent voltage regulator, static exciter parameters like K_A, T_A, …
- Reserve management	⇒	Schedule for secondary, tertiary reserves
- Demand response	⇒	Schedule for demand response capability

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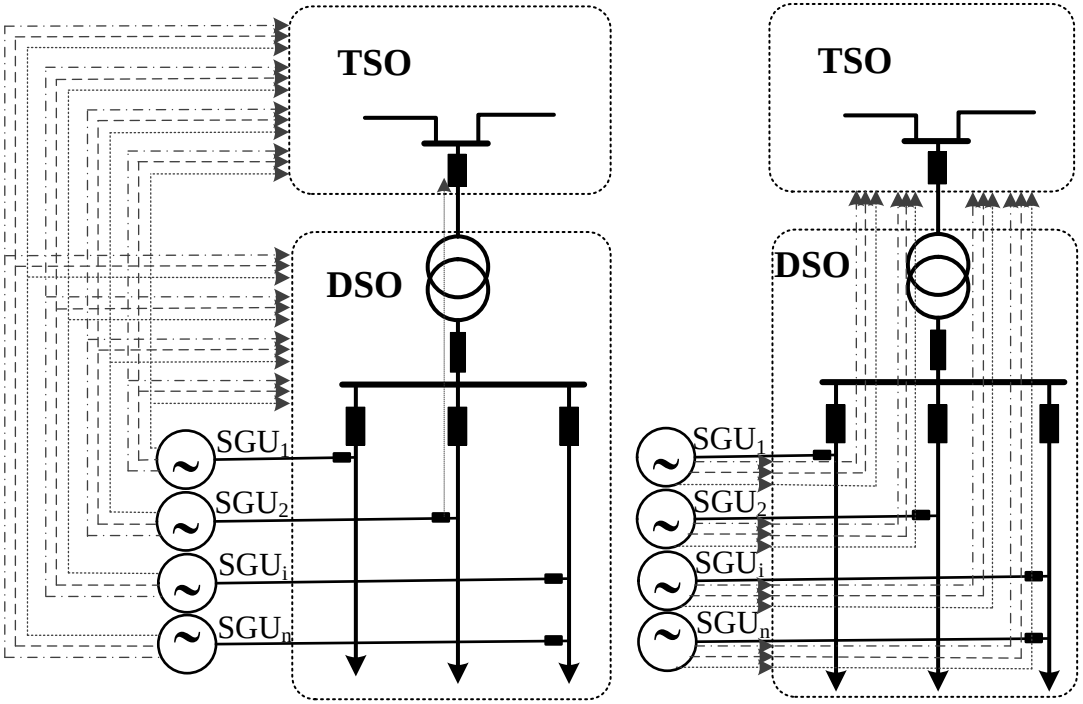
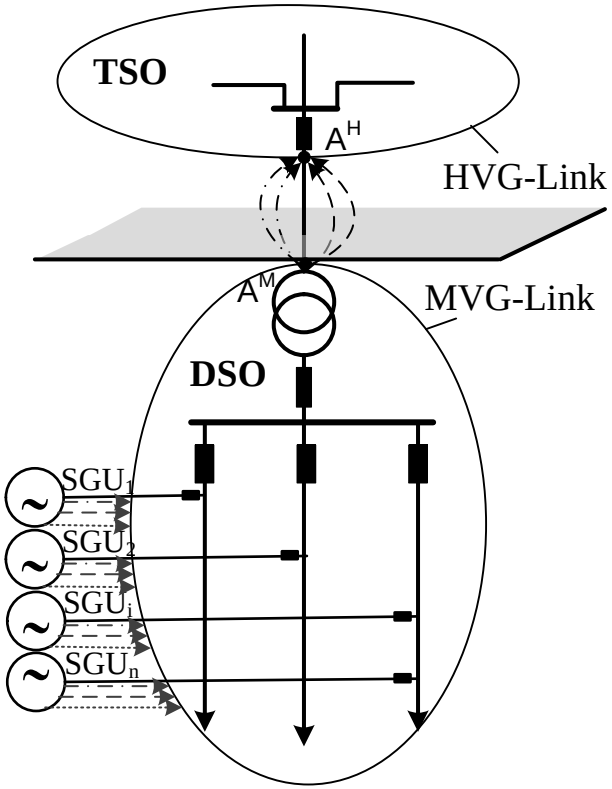
Data flow between DSO, TSO and Significant Grid Users based on:

Article 25 and 29 of the Network Code on Operational Security



Unified, distributed *LINK*-based Operation Architecture



Number of exchanged schedules ⇒ **3·*N*** **4**

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

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Conclusions

- The unified, distributed *LINK*-based operational architecture establishes a suitable framework for the realisation of Smart Power Systems.

- It facilitates all actual power system operation processes like demand response, load-generation balance, voltage assessment, outage managements, etc.

- The amount of information which necessarily should be exchanged between TSOs, DSOs and Significant Users is minimized.

- The danger of cyber-attacks from outside is thereby reduced drastically.

- TSO and DSO will share only a small set of absolutely necessary electrical data with each other.

- The proposed unified, distributed *LINK*-based operational architecture postulates the change and simplification of Network Code on Operational Security.

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Thank you for your attention

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