

Sustaining Security of Supply in the Future: Challenges and Opportunities of the holistic LINK-Solution

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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

Microgrids

...“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.**”...

. . . 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

After more than 15 years research the question arises:

Are these concepts

Virtual Power Plants

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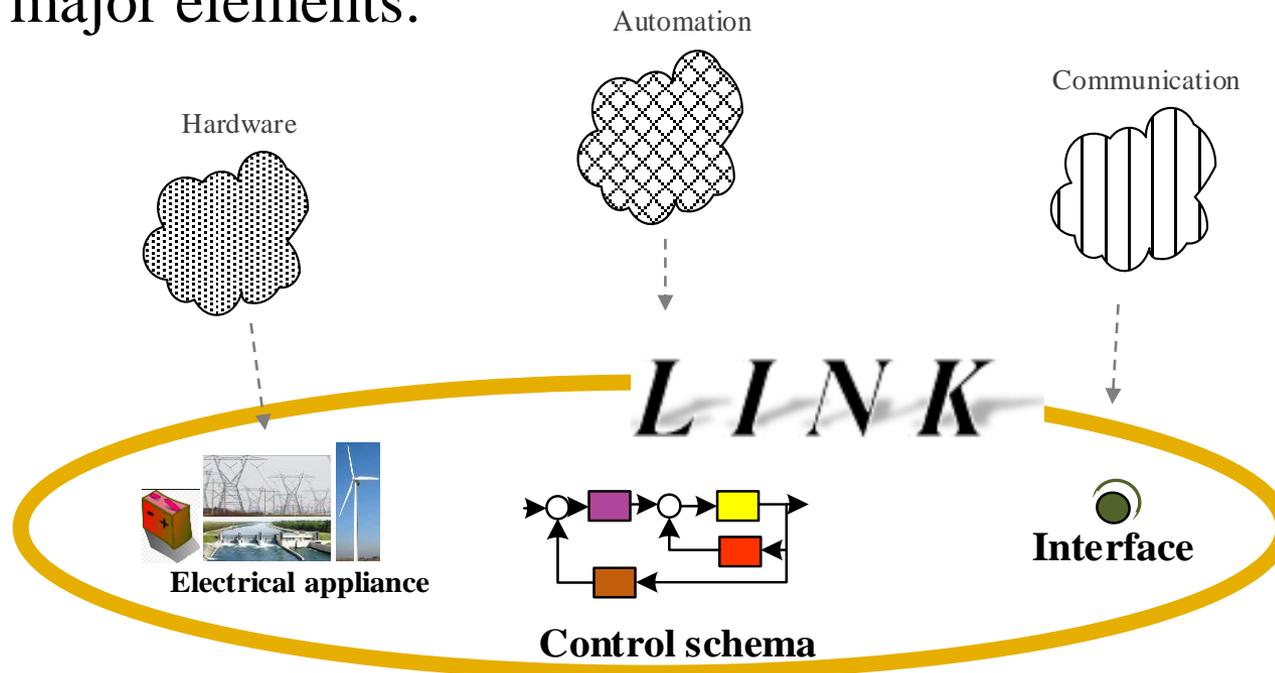
Microgrids

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

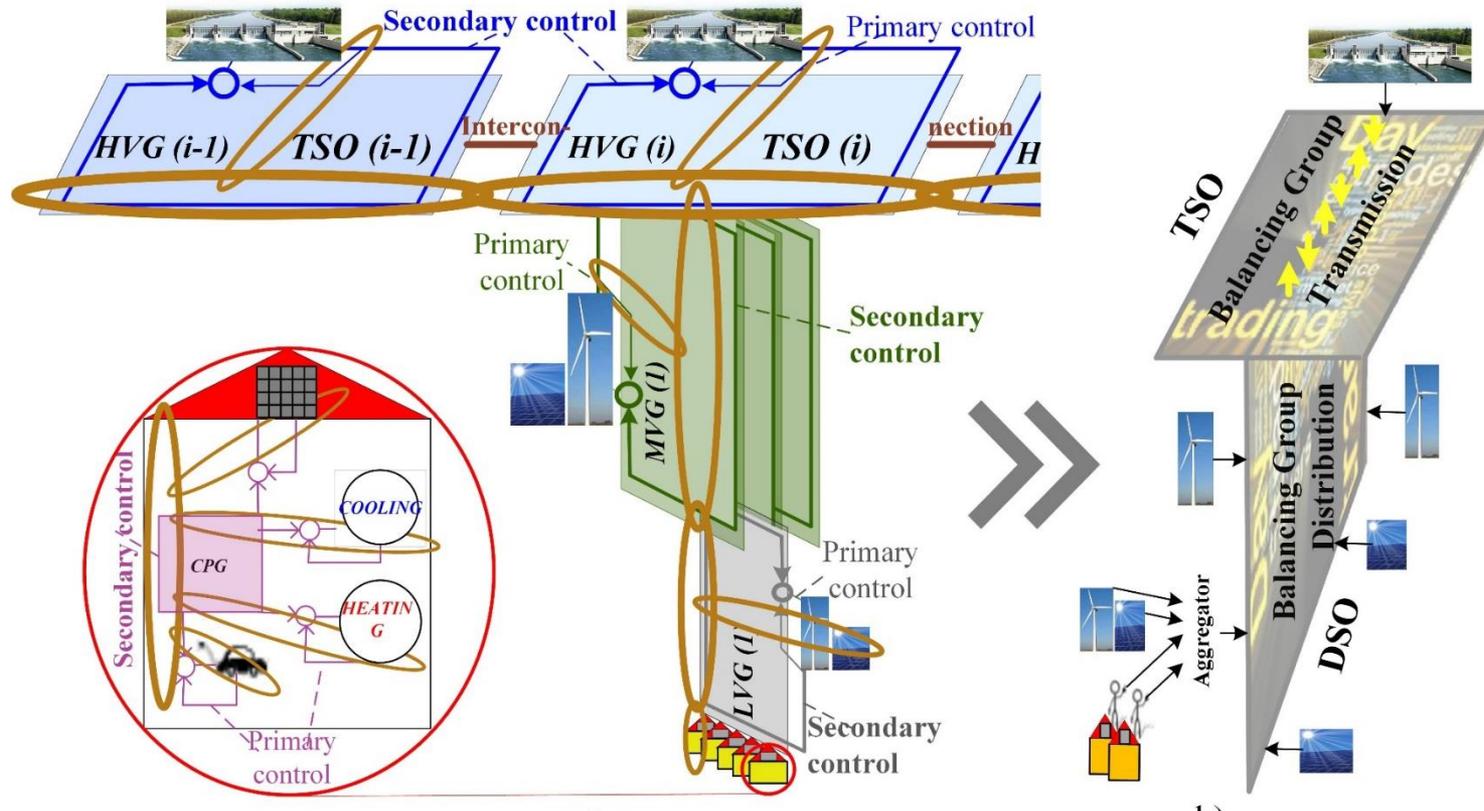
Source: A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", Electric Power Systems Research - Journal – Elsevier, Volume 131, 2016, pp. 116-125.

“LINK” – The Smart Grid Paradigm

A technical system consists of three major elements:



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 .

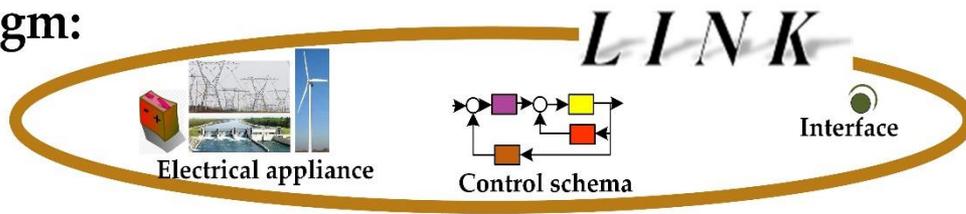


“Energy Supply Chain Net” is an holistic technical model for power systems that consists of a set of automated power grids, intended for chain links, which fit into one another to establish a flexible and reliable electrical connection. Each individual link or a link-bundle operates autonomously and have contractual arrangements with other relevant boundary links or link-bundles.

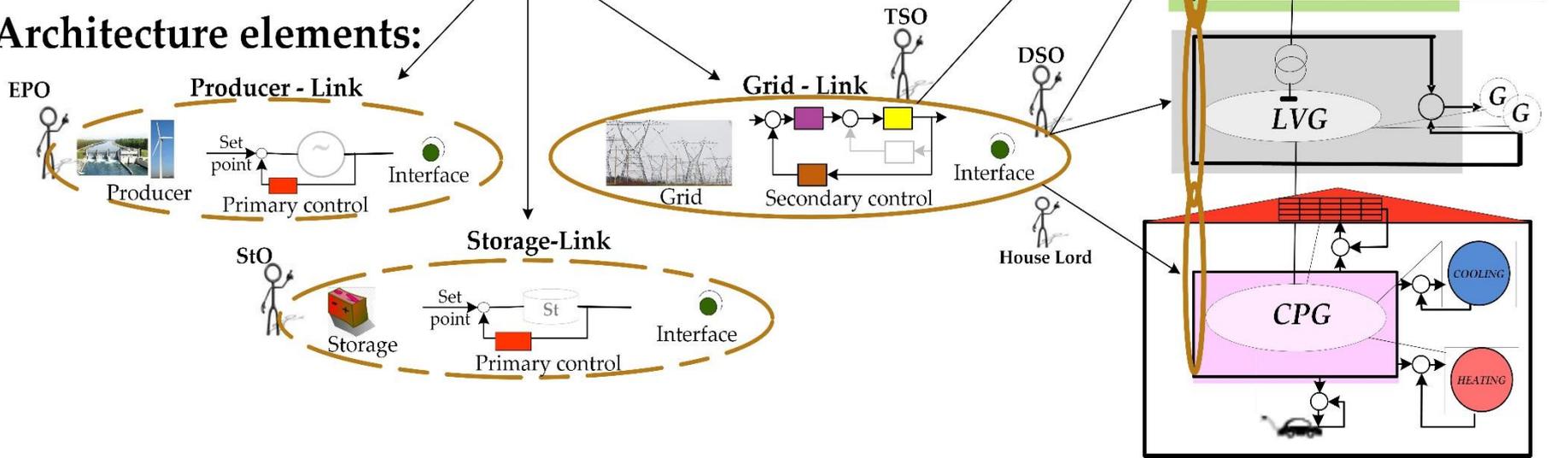
Market holistic model is a mirror of the technical holistic model.

Architecture Elements

Paradigm:



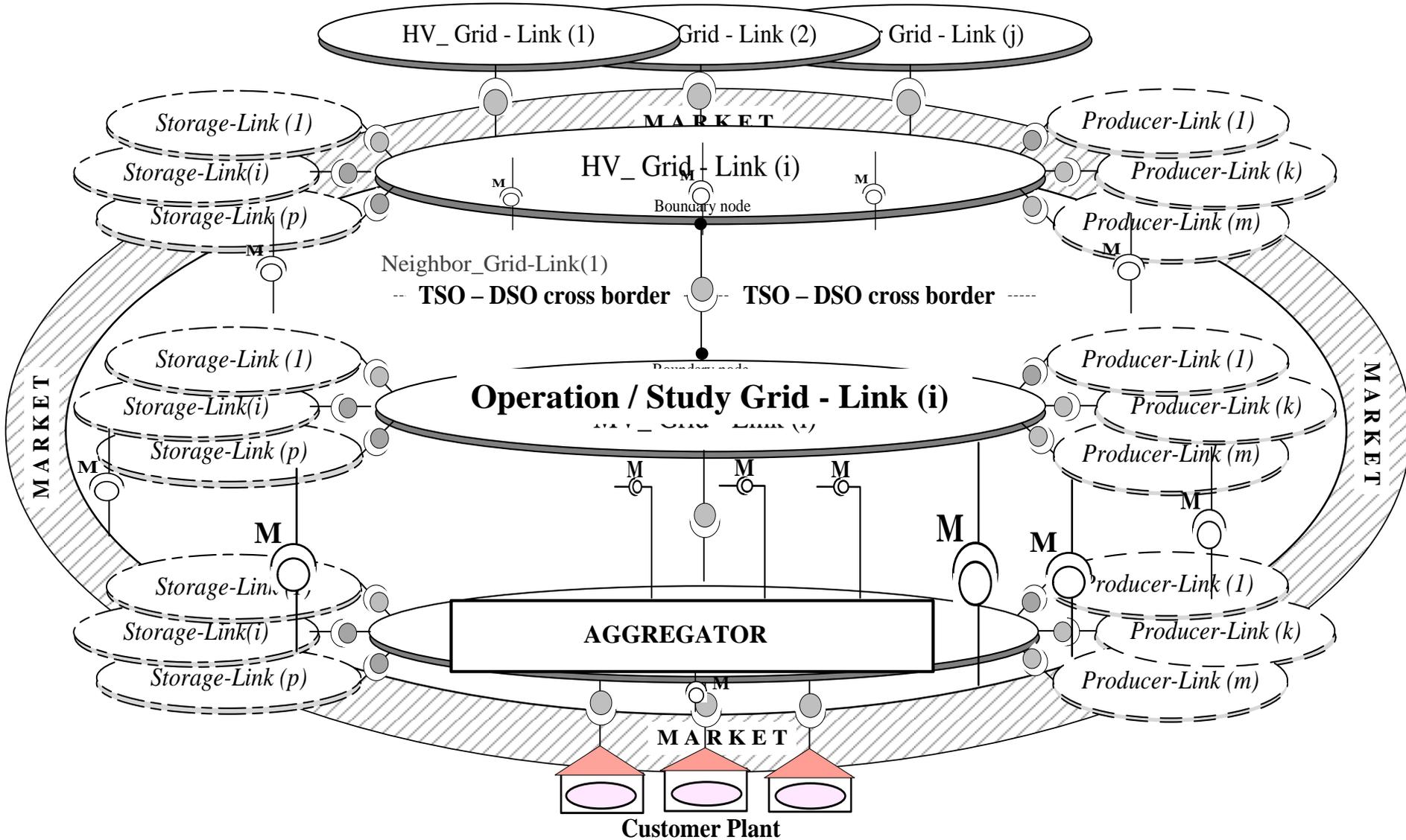
Architecture elements:

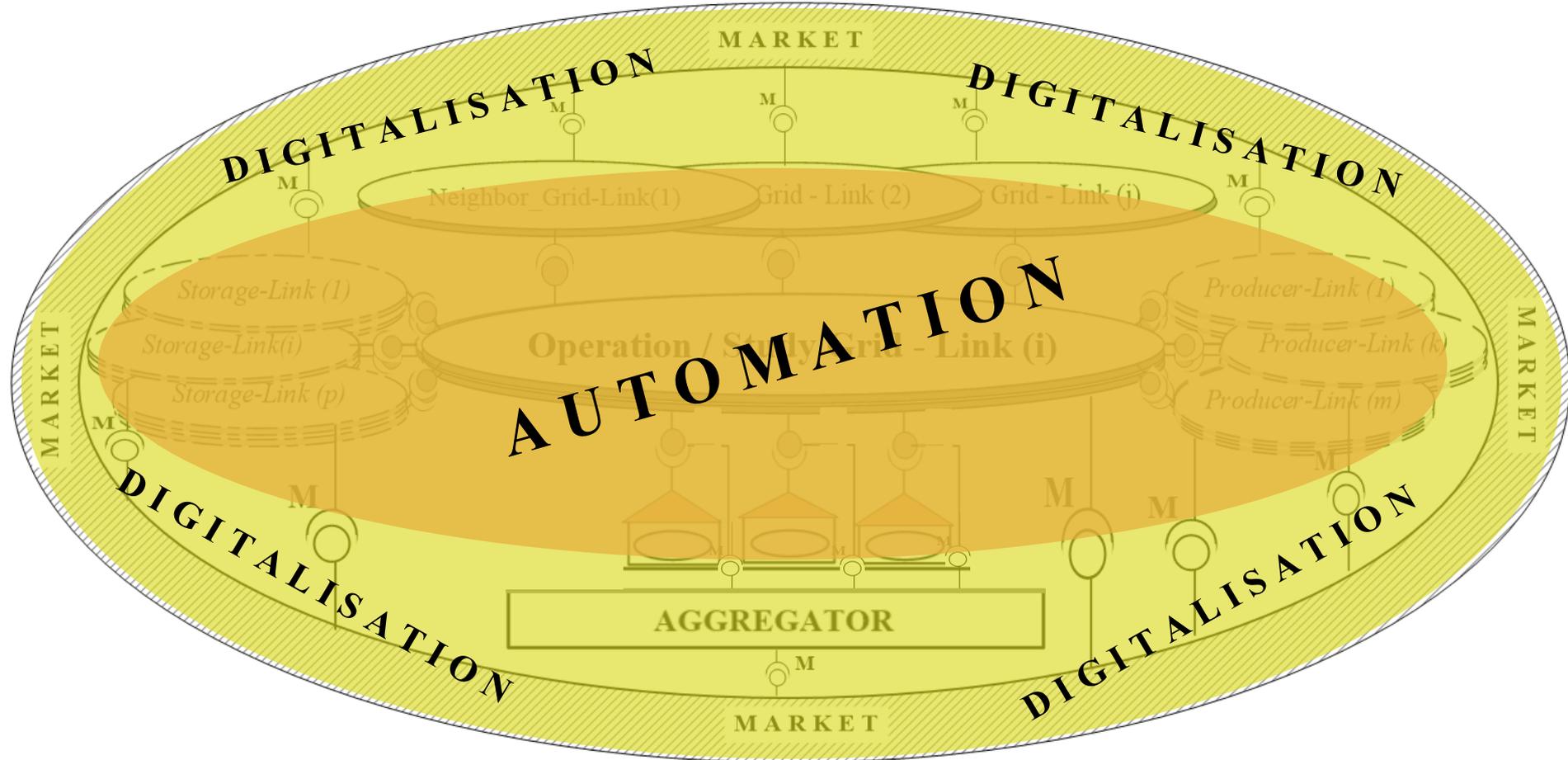


Source: A. Ilo, "Link- the Smart Grid Paradigm for a Secure Decentralized Operation Architecture", *Electric Power Systems Research - Journal* – Elsevier, Volume 131, 2016, pp. 116-125.

Generalized NK-based architecture of smart power systems and electricity market

Technical-functional architecture of smart power systems



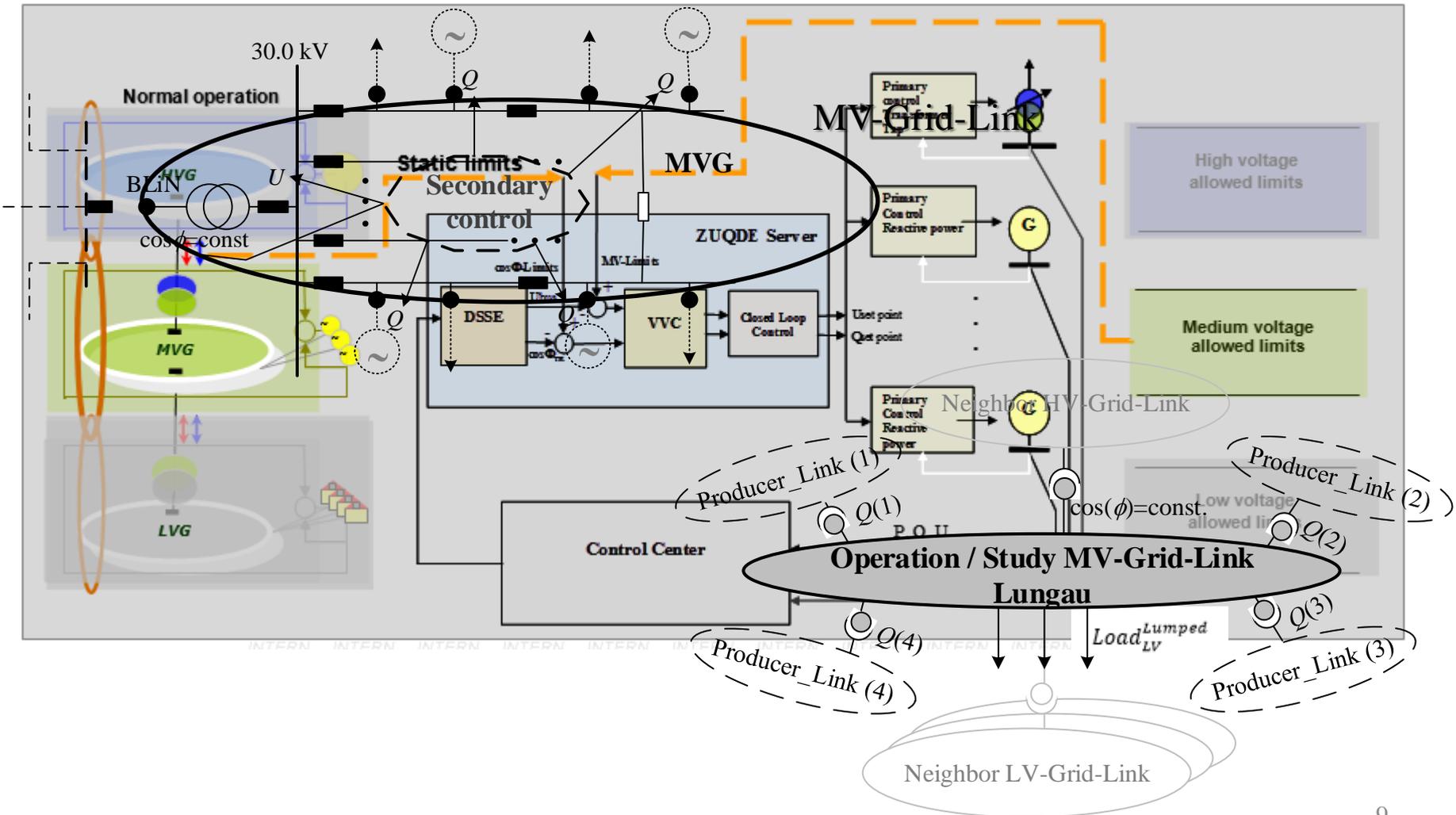


Automation is crucial for the future power systems

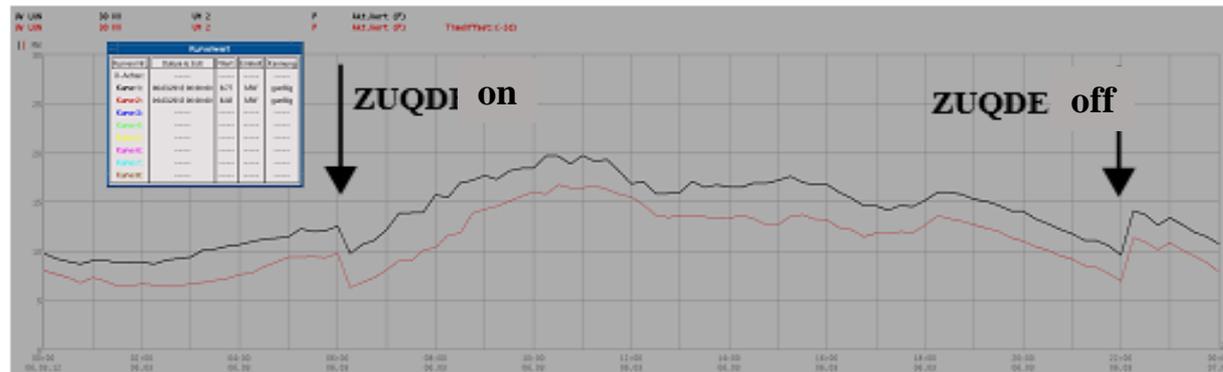
Effective use of digitalization is possible only after automation 8

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

Reactive power and voltage control



Operation results of MV_Grid-Link within the framework of ZUQDE project, Salzburg, Austria.



Voltage and load reduction potential

| Time | Loading case | Supplying transformer loading [MW] | Voltage reduction [%] | Load reduction [%] |
|--------------|---------------|------------------------------------|-----------------------|--------------------|
| Day 1: 15:38 | average | 16,7 | 4,33 | 6,53 |
| Day 1: 16:00 | average | 17,0 | 4,67 | 7,06 |
| Day 2: 21:37 | minimal | 9,7 | 4,33 | 4,67 |
| Day 2: 22:13 | night current | 12,8 | 4,33 | 6,57 |

Energy saving potential

From literature* "... 1% reduction in voltage results in an average 0,4 - 1% reduction in energy consumption ..."

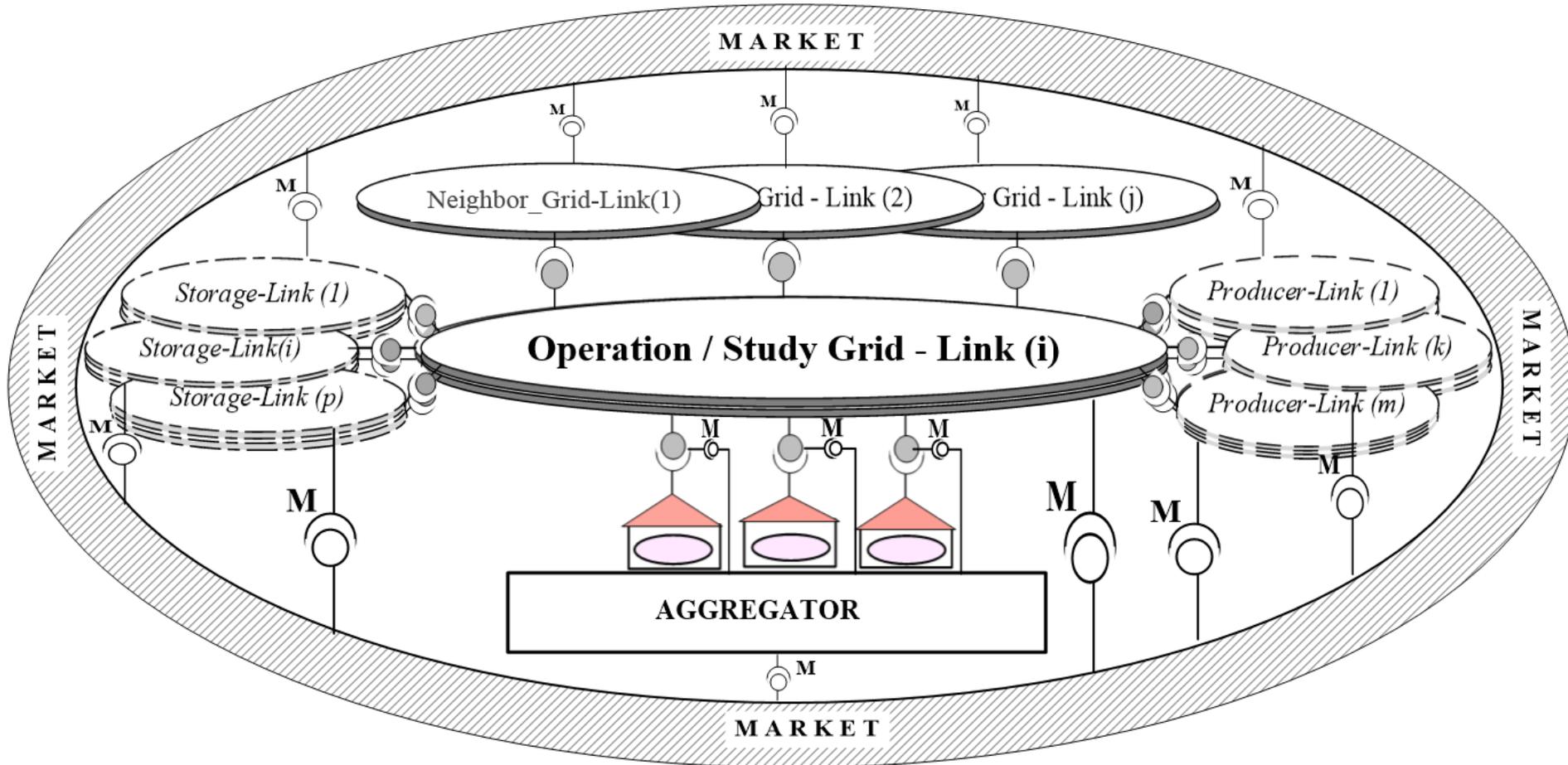
Expected: circa 2% energy saving

*Measuring the efficiency of voltage reduction at Hydro-Québec distribution, IEEE 2008

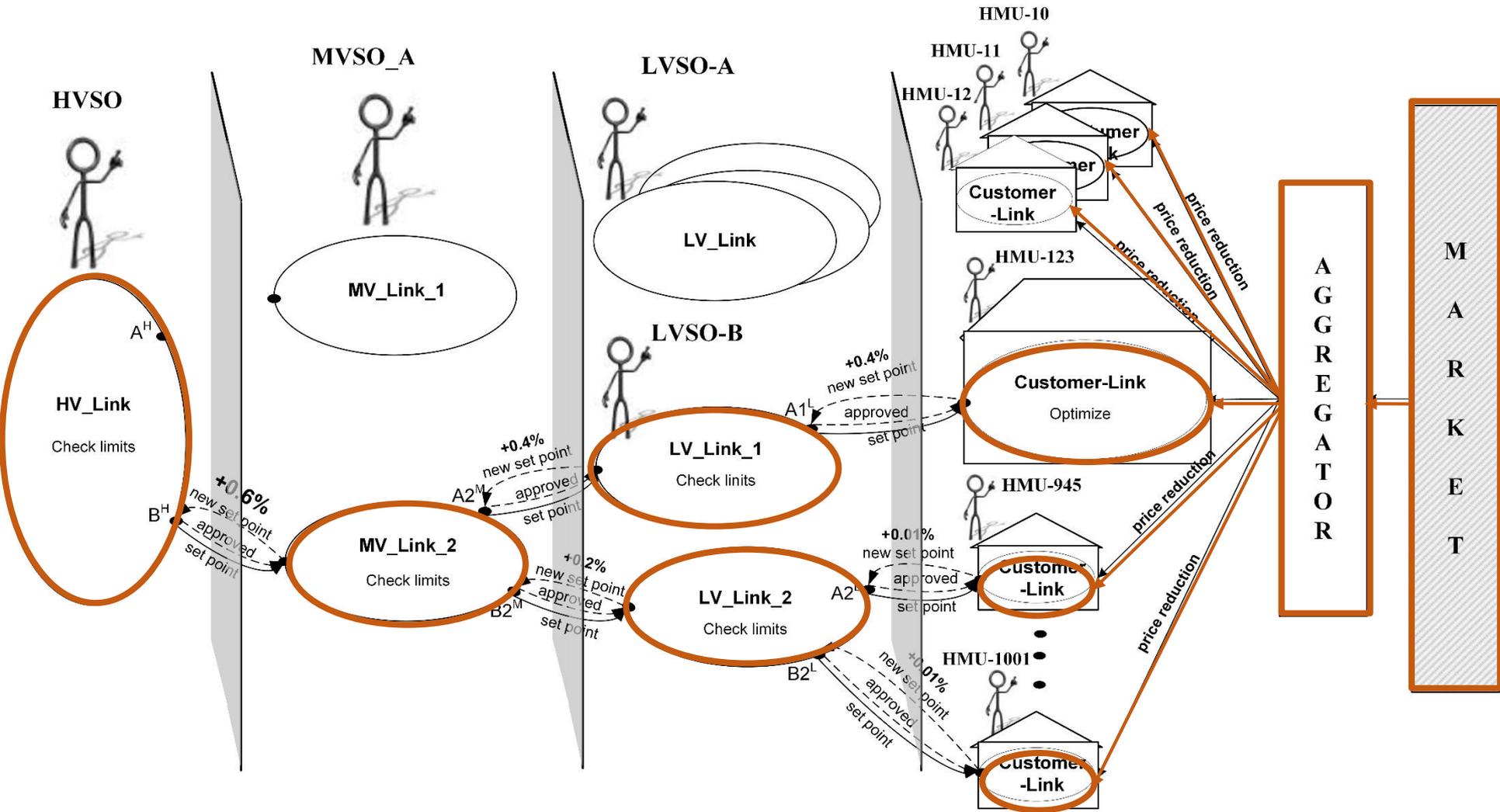
ENTSOE-E overall electricity consumption in 2015 → 3,278 TWh

2% energy saving → 64.56 TWh

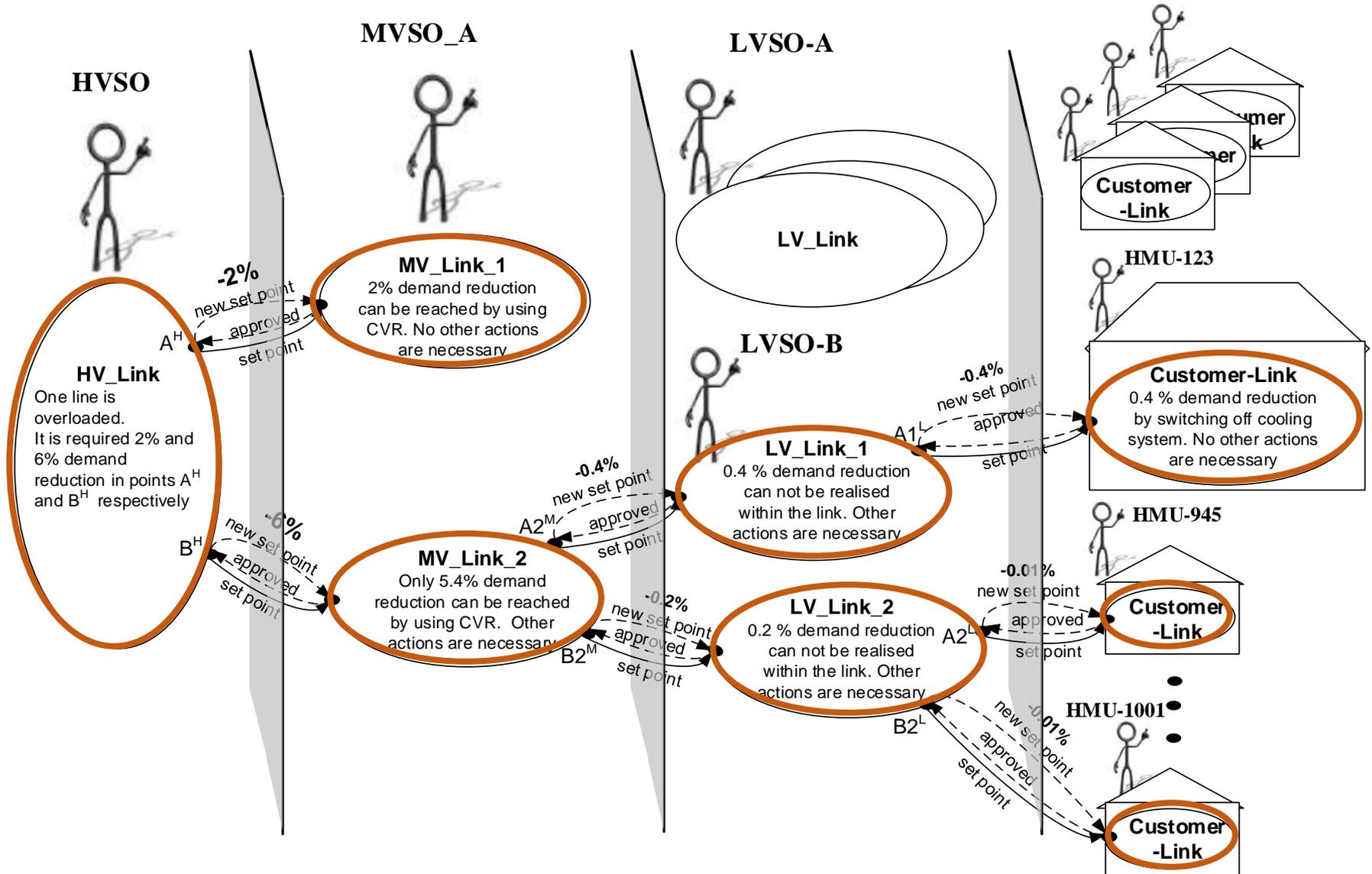
Demand response process: line overload on high voltage grid



Demand response process: real-time pricing

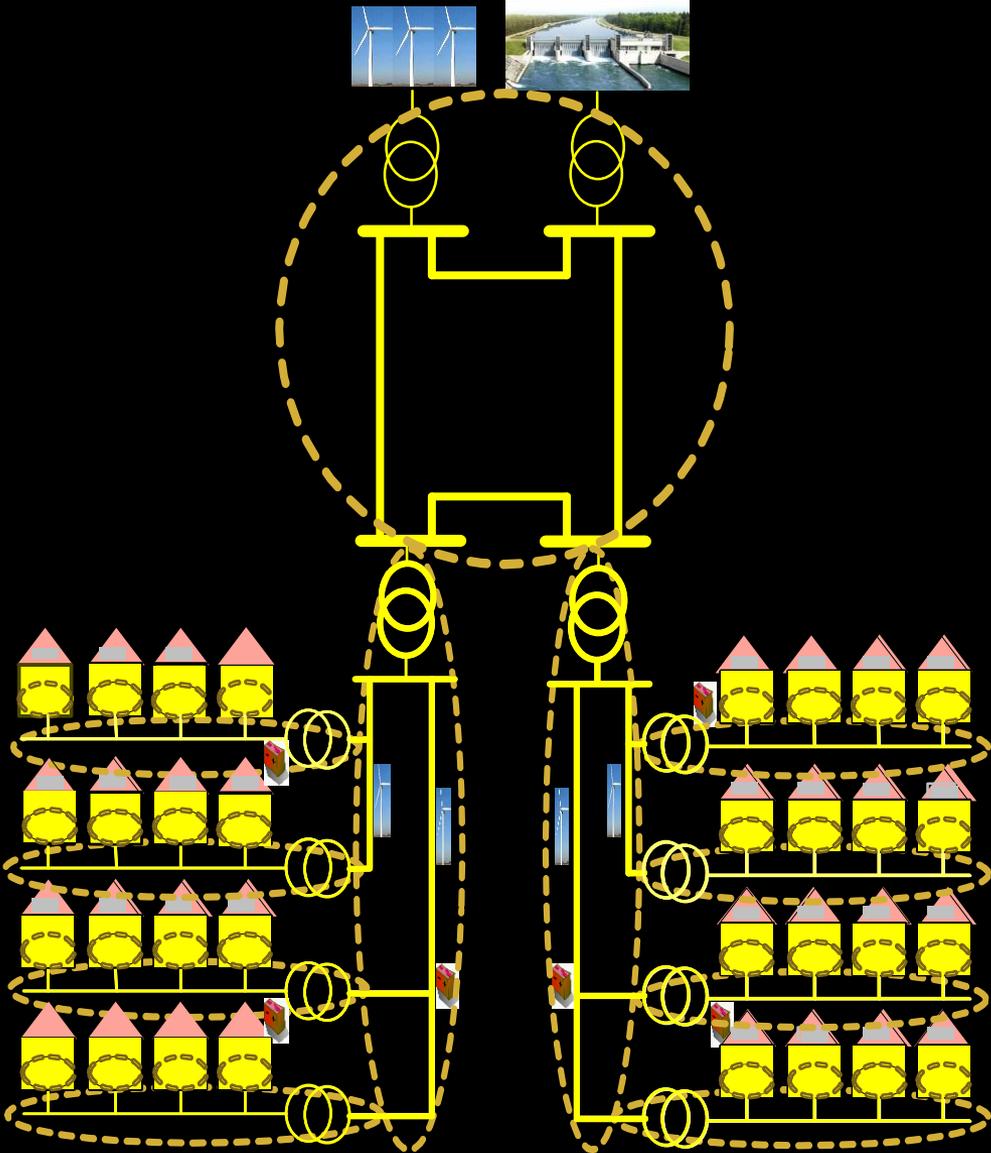


Demand response process: line overload on high voltage grid



Restauration in case of total black out:

Power systems using the *LINK*-based architecture



- The unified *LINK*-based holistic architecture brings under one umbrella the entire power system, the customer plants and the electricity market.
- “*LINK*” – solution facilitates the integration of renewable distributed energy resources in large scale thus enabling the decarbonisation of power industry.
- Automation and digitalization are crucial for the realisation of *LINK*-solution.
- To guaranty the security of supply, automation should have the priority in the implementation process .

Thank you for your attention

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