

# Recovering process after a total blackout in the case of *LINK*-based holistic architecture

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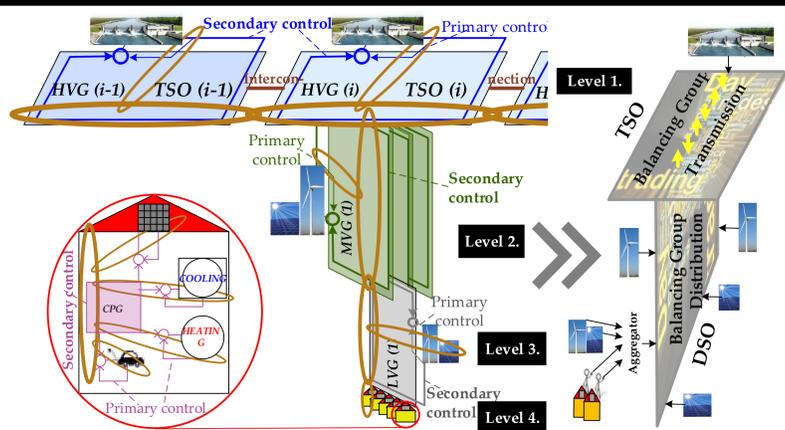
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## Abstract

The big blackouts are extreme scenarios of power outages that rarely occur. They are associated with enormous economic and social damages. Power restoration is complex and time critical. In the traditional centralized power systems, it takes a few hours to days to complete all steps described in the system's recovery plans. The integration of distributed energy resources does not fit into the existing power system architecture. Their

comprehensive integration increases the likelihood of blackouts. The application of the distributed *LINK*-based holistic architecture indicates a more sustainable and resilient future of power systems. The load is partially supplied within one to two hours by changing the operating mode from "normal-autonomous" to "autarkic-recovery". The total load is supplied within a couple of hours, mitigating the vast economic and social damages.

## Holistic model

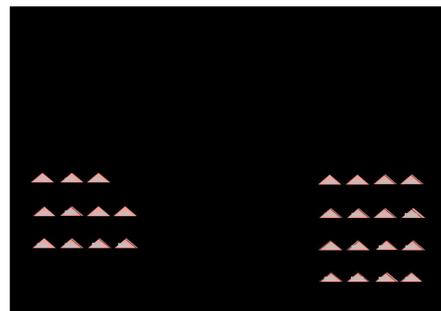


a) HVG - High Voltage Grid MVG - Medium Voltage Grid LVG - Low Voltage Grid CPG - Customer Plant Grid  
Overview of the holistic model: a) technical "Energy Supply Chain Net"; b) market-related

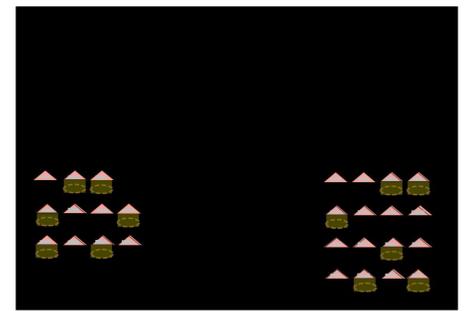
## Recovering process after a total blackout

The following hypothetical case is considered. *LINK*-Solution is successfully implemented in all affected areas. All Links operate as designed. It is a sunny and hot summer day, when at 1 pm a total blackout occurs. About 85% of customer plants have already installed PV systems. Distributed electricity producers and storages are installed in low and medium voltage grids.

1 pm



After 5 min



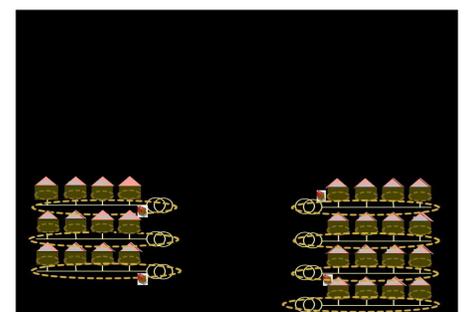
All customer plants with installed PVs have the opportunity to supply individually at least their minimal load by changing the operation mode from "normal-autonomous" to "autarkic-recovery".

Within 5 min, some of the customer plants with PV have set the operation mode to "autarkic-recovery" and have partially supplied the load, **Level 4**.

After 10 min



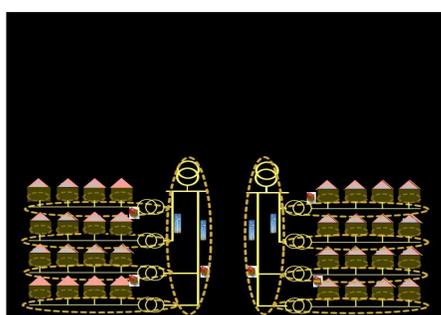
After 60 min



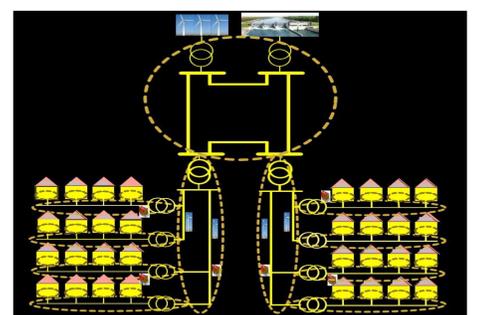
After 10 min, almost all of the customer plants with PV have set the operation mode to "autarkic-recovery" and have partially supplied the load, **Level 4**.

Within one hour, in each LV-Link bundle is set the operation mode to autarkic-recovery, thus supplying partially the customer plants without PV installation, **Level 3**.

After 120 min



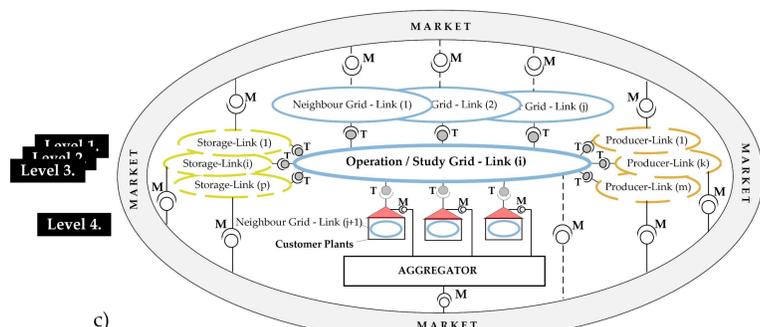
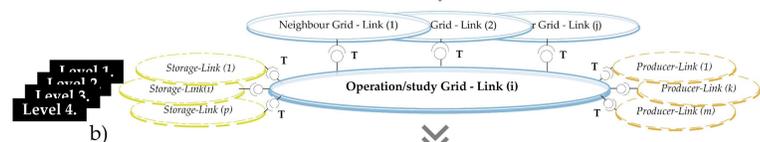
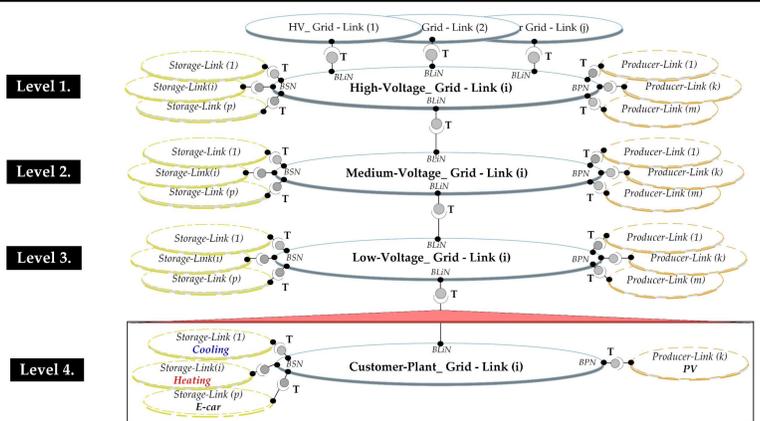
After a couple of hours



Within two hours, in each MV-Link bundle is set the operation mode to autarkic-recovery, thus supplying partially all customer plants which couldn't be supplied individually or by the LV-Link bundles. At least the minimal load of all customers is supplied, **Level 2**.

Within a couple of hours, the HV-Link bundle have recovered and the full load is supplied, **Level 1**.

## Different levels of *LINK*-based holistic architecture



Different architectural levels: a) technical/functional b) generalized and c) holistic

## Operating modes

The new designed holistic architecture facilitates two operating modes:

1. **Autonomous** - each individual Link operates independently by respecting the contractual arrangements with other relevant boundary Links. All Links are connected together creating a large power system.

2. **Autarkic** - is an optional operating mode, which may be applied in any Link-bundle, which consists of at least one Grid-Link and one Producer-Link or Storage-Link, as long as it is self-sufficient and -sustaining without any dependency on electricity imports.

- **Restoration** - is an option of the autarkic operating mode, which may be applied after a blackout, during the restoration process to supply with electricity at least the communication appliances.

## Conclusion

The implementation of the distributed *LINK*-based holistic architecture contributes by design to the damage prevention, because it assures a harmonised operation of the distributed resources with the rest of the power system, customers and market, thus increasing the sustainability and resiliency of power system. In the blackout case, the system recovery time is drastically reduced, thereby mitigating social and economical damages.