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Distributed Control Concepts using Multi-Agent technology and Automatic Markets

An indispensable feature of smart power grids

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Why decentralized control?

- Privacy
- Autonomy
- Scalability
- Communication overhead



Three stages of DG Growth

Growing DG Penetration

Accommodation

- DG accommodated in the current system
- DG units running free
- DG treated as negative demand
- Central control unchanged

Decentralization

- Added value of clustered control of DG.
- Common ICT systems: Virtual Utilities, Virtual Power Plants.
- Central control still needed
- Decentralized, bottom-up control is added.

Dispersal

- Distributed power dominates the market
- Network of networks
- Local network segments selfsupplying.
- Central controller
 becomes a
 - coordinator.
- Source: IEA, 2002

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Current practice in load control

- Centralized control
- Reactive customers
- Traditionally focused on customer demand
- Undetermined outcome



PowerMatcher control

- Decentralized control
- Active customers
- Transparency with respect to demand and supply
- Determined outcome by 'real-time' contract
- Dynamic response



PowerMatcher cells - networks of networks



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Business cases

- Imbalance reduction for responsible party (CRISP)
- Keeping self-generated power in-house (UPM)
- Flattening generation and consumption patterns
- Intelligent substation control: peak reduction (SPS First trial); towards islanding
- Virtual Power Plant control (FENIX)
- Storage optimization (plug-in hybrids)
- •



CRISP Field test: Portfolio



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CRISP



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SPS First trial



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SPS First trial

14000 SubstationLoad Substation Conv Substation Load 12000 Substation Load SDM 0.5 Substation Load SDM 1 Substation Load SDM 2 SDM Substation load 5 10000 8000 6000 [W] peor 4000 2000 0 201 301 101 401 501 601 -2000 -4000 -6000

Winter Situation comparison space temperature bandwidth

Time steps [15 minutes]

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FENIX (Northern demo) Overall System Architecture DEMS **DEMS** Application Web Access VPP Concentrator Box 4 SCADA Server Wind generation Internet Woking Council & EDF - -EDF Energie Nouvelle Energy **G**1 G1 **G**1 G1 Woking Swimming Pool & Imperial College Labs Fenland Glass Moor Windpark (8 Re-Power MM2 2MW each – total 16MW) VPP Concentrator 1 & 2 VPP Concentrator 3 (Existing CHP SCADA) -P Fenix Box Load under Demand þ þ 33KV Response SS Horsell SS L1 L2 Woking \mathbf{O} \odot 0 G1 P G3 Load under PV Cell 11KV_ Demand Side Old Woking SS Management G2 Working CHP Portfolio (total 4MW)

> Fenix Northern Scenario – AREVA Proposal

T&D

2

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- Connectivity for:
 - Small scale wind
 - PV(T)
 - μCHP
 - Heat pumps
 - Household appliances
- UPS Functionality on a household level
- Connectivity with other UPMs







Upcoming research

- Integral
- Active houses
- 6 scenario simulations
- Network constraint handling



Conclusions

- Distributed control concepts create:
 - scalability
 - local autonomy
 - market integration
- The PowerMatcher provides a flexible concept to implement a variety of business cases
- Different business cases proven in Field tests
- Embedded trajectory as a first step to commercial products