



DSOs Using Demand-Side Management Techniques For Reducing Congestion Issues: The Case of ASM Terni

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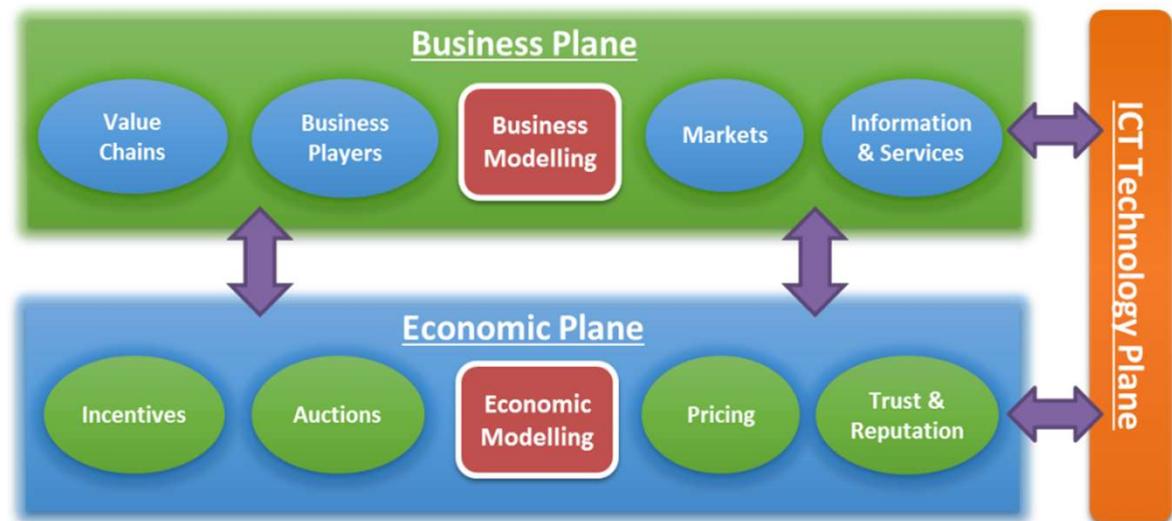


What we do at STEcon

We investigate, develop and apply concepts, and mechanisms where ICT technology, business and economics “meet” in a multitude of application areas:

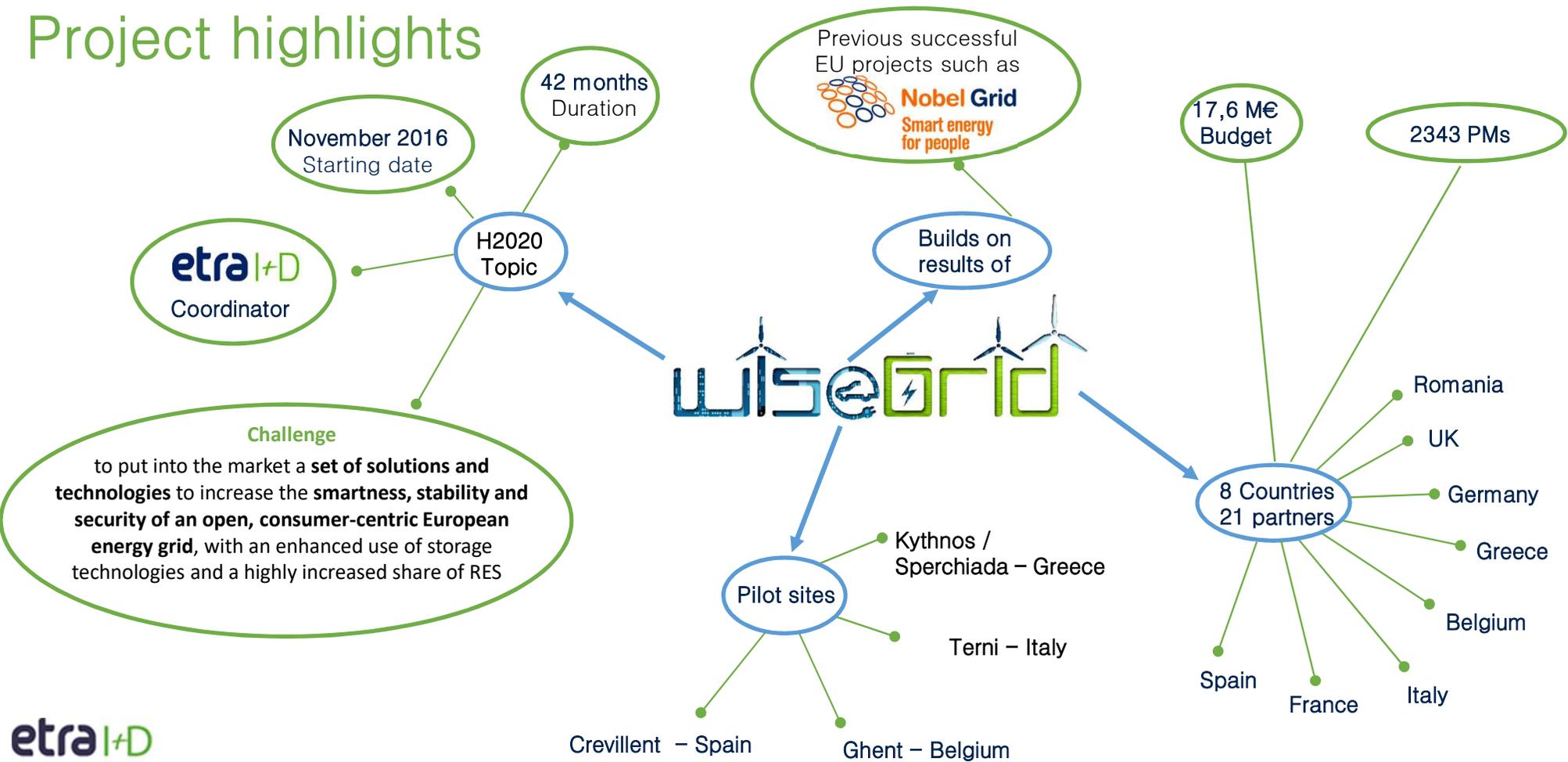
- Energy and smart grids
- Telecommunications and 5G
- Cloud computing
- Internet of Things
- Smart water networks
- E-markets
- ...

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Project highlights





Purpose of the paper

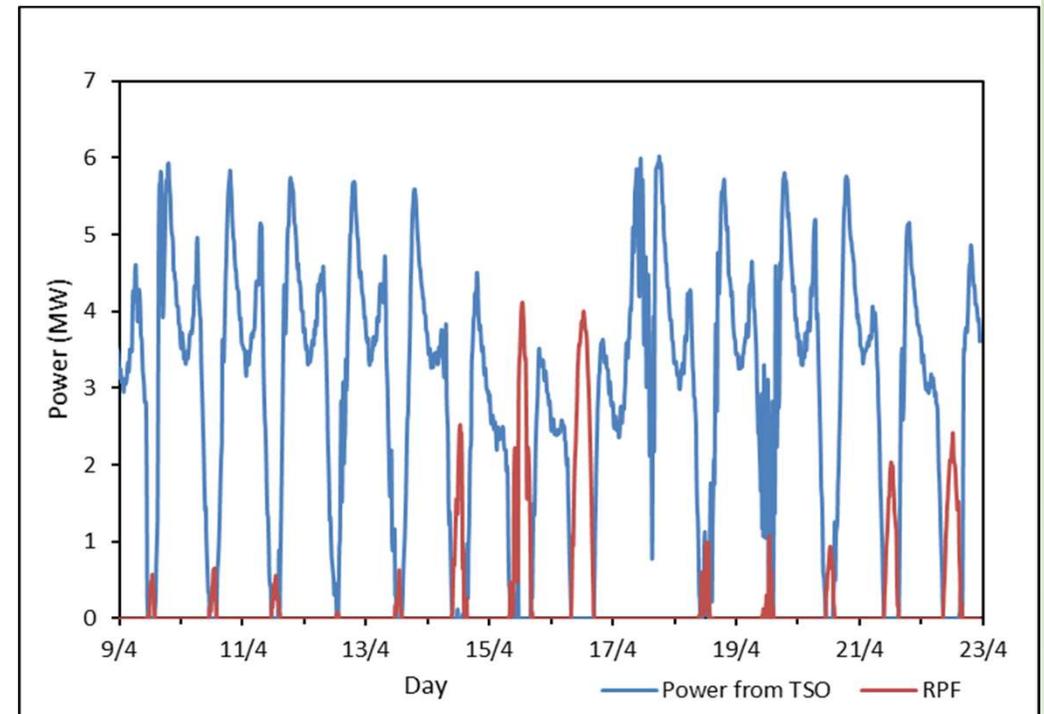
- We focus on the effects of the renewables and Electric Vehicles (EVs) on the LV/MV network and assess the potential of Demand Side Management techniques in dealing with the associated technical issues.
 - Congestion on MV/LV feeders due to Reverse Power Flows (RPF) or High Loads
- Identify the market conditions that render Demand Side Management services both attractive and commercially viable
 - Win-Win for both DSOs and Aggregators



Motivation

- Most LV feeders were over-dimensioned so congestion events rarely happen today
 - Mostly due to hardware failure, maintenance, etc
- These events are expected to be more frequent in medium & upper class neighborhoods due to
 - presence of many EVs that are charged simultaneously
 - deployment of many PVs
- Congestion may lead to outages

Reverse Power Flows for a single primary substation, Week 11 2017





A simulation-based study

- A custom **LV/MV feeder simulator** was developed and utilised for obtaining values for **key technoeconomic metrics**, such as:
 - How much **flexibility would a DSO ask** during the next 20 years, how frequently and what is its willingness to pay for such services?
 - What is the expected **flexibility offered** by different types of participants to Demand-Response campaigns during the next 20 years and what is the effect of technology (such as Electric Vehicles and smart controllers) and rewards?
 - What is the annual **injected energy** of different types of consumers/prosumers (with PV, EV, battery, smart home controller, etc.).



Overall Simulation Approach

Techno-Economic parameter values
and assumptions (from experts)



Key
technoeconomic
KPIs



Knowledge via
BM financial
KPIs

Economic Parameter values
(from experts)





STEcon LV/MV feeder Simulator

• Supported Types

- EV presence (load-only)
 - Yes
 - No

Additional options

- Consumer
- Prosumer
- Hybrid Prosumer
- Prosumer w. leased PV
- Hybrid Prosumer w. leased PV, battery
- Managed MicroGenerator (as a member of a VPP)
- Distributed Generator

Additional options

• DR participation

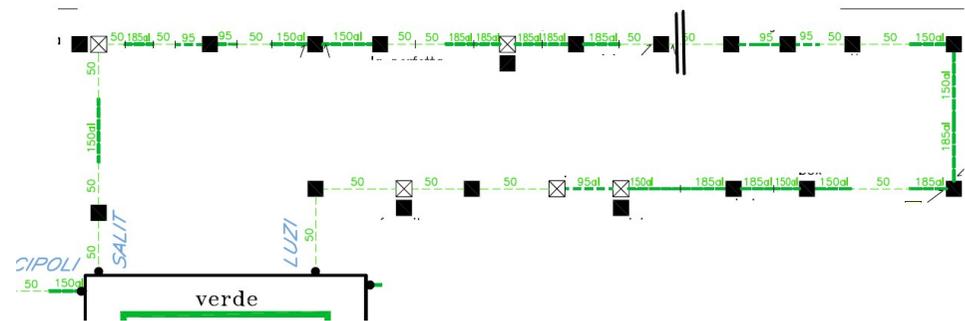
- ADR only
 - Negative/positive flexibility
- reward-based MDR only
 - Negative/positive flexibility
- Both ADR & rbMDR



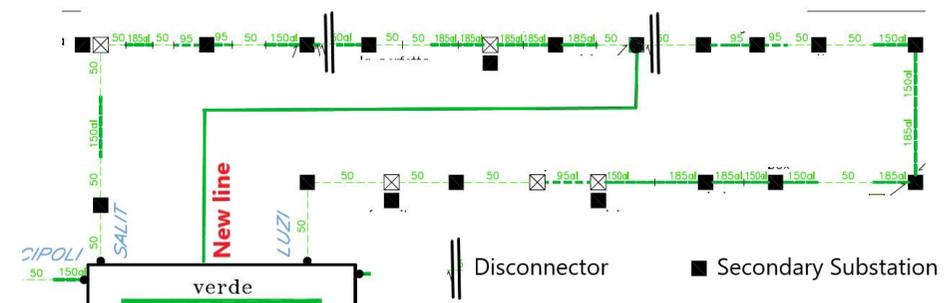
DSO Options explored

- We will explore 3 candidate options for ASM Terni:
 - Option1 (Business-as-Usual scenario): upgrade network by installing **a new LV line in 11 areas** and assume that congestion issues are definitely avoided.
 - Option2 (DR): ask flexibility from Aggregator (assuming that flexibility needs are perfectly known, which means 100% accurate demand forecasting)
 - Option3 (Do nothing): pay penalties for outages

Option 1 (before)



Option 1 (with new line)

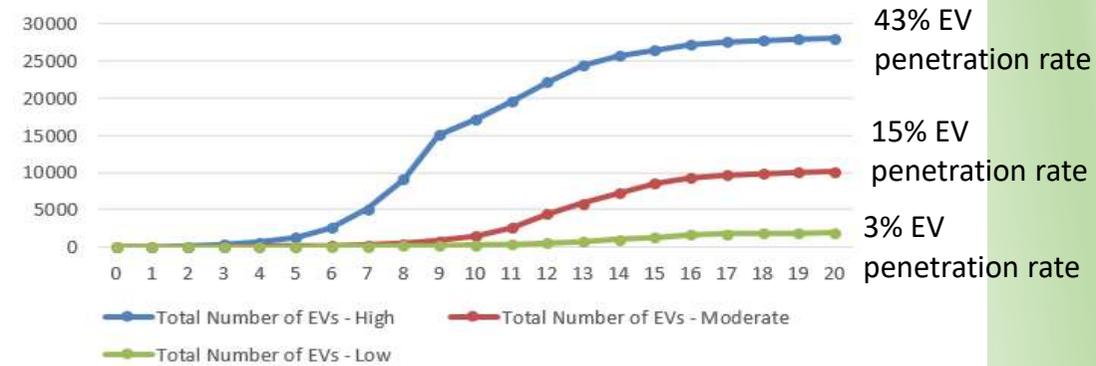




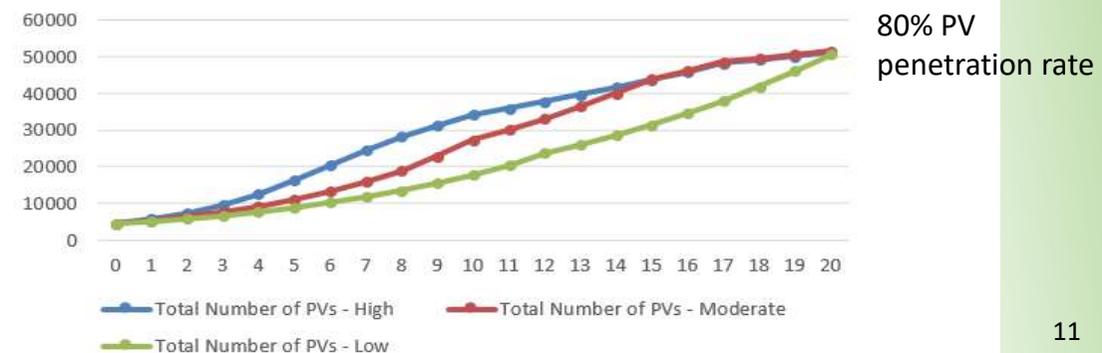
Key assumptions

- Congestion events depend on the following factors:
 - Network capacity and topology
 - Load profile
 - Load flexibility
- We defined three scenarios based on the **EV and PV increase rates**:
 - <Low EV increase rate, Low PV increase rate>
 - <Moderate EV increase rate, Moderate PV increase rate>
 - <High EV increase rate, High PV increase rate>

Candidate future EV adoption paths



Candidate future PV adoption paths



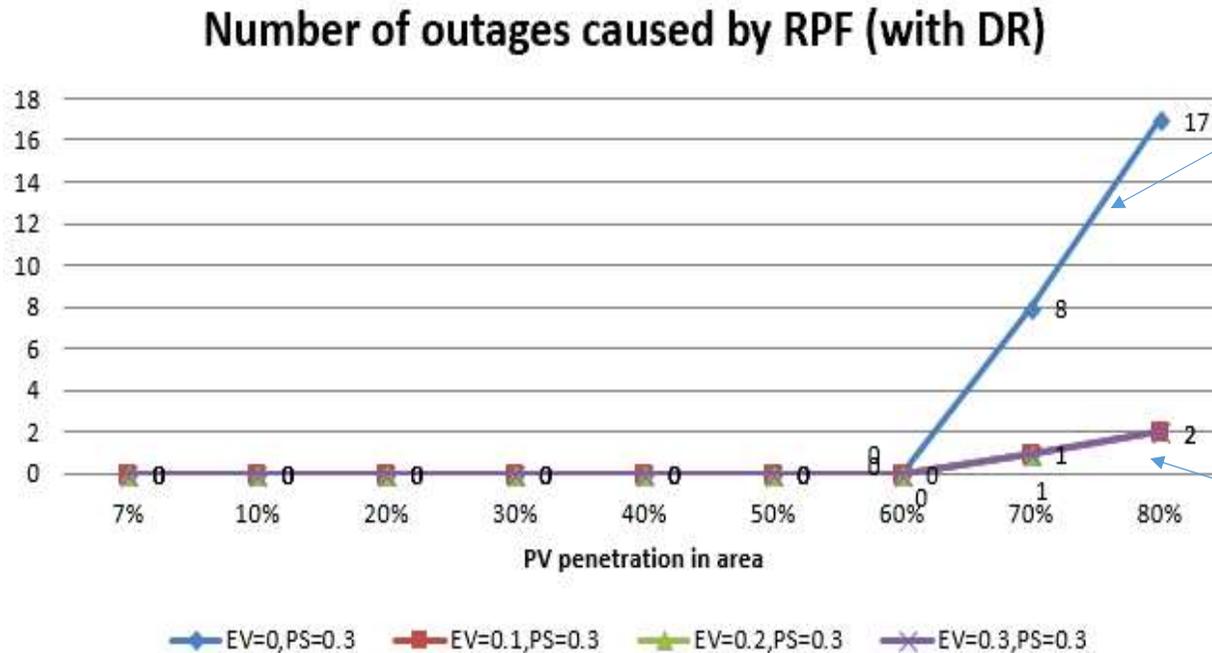


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Simulation outputs



Number of annual outages due to high RPF and DR effect



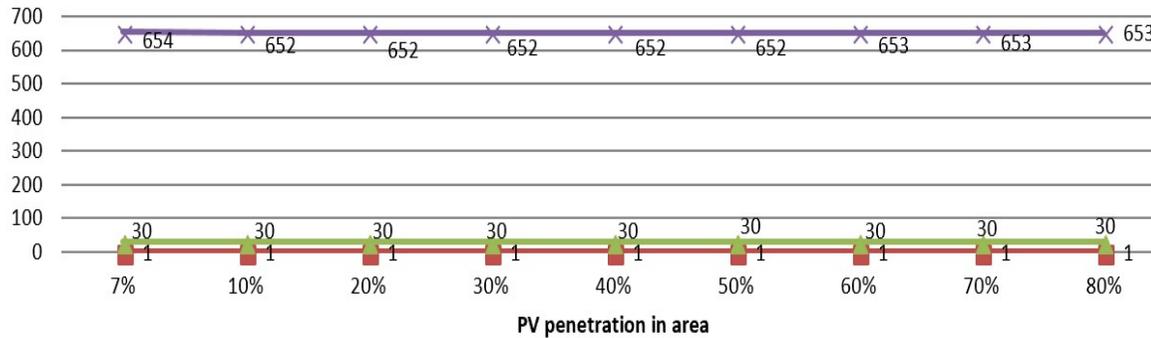
MDR alone
(no EVs)
did not avoid
any outages

Flexibility from
EVs is key for
reducing number
of outages



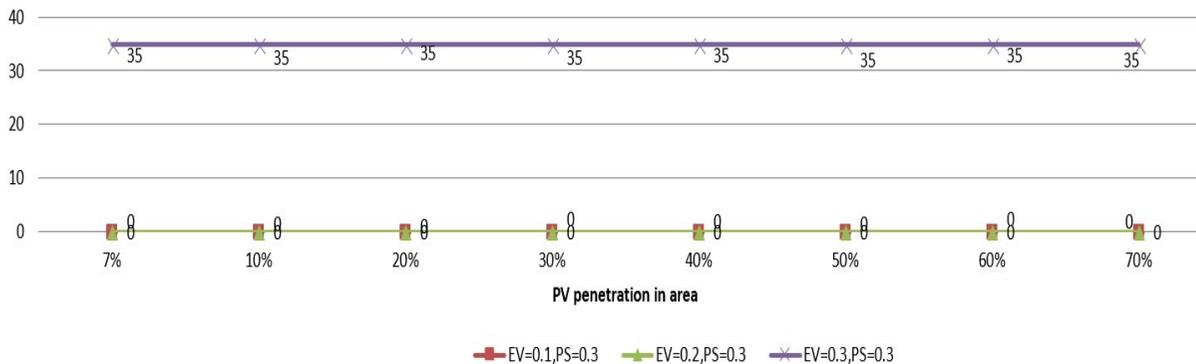
Number of annual outages due to high loads and DR effect

Number of outages caused by high loads (BaU)



Number of outages is insensitive to PV penetration

Number of outages caused by high loads (with DR)

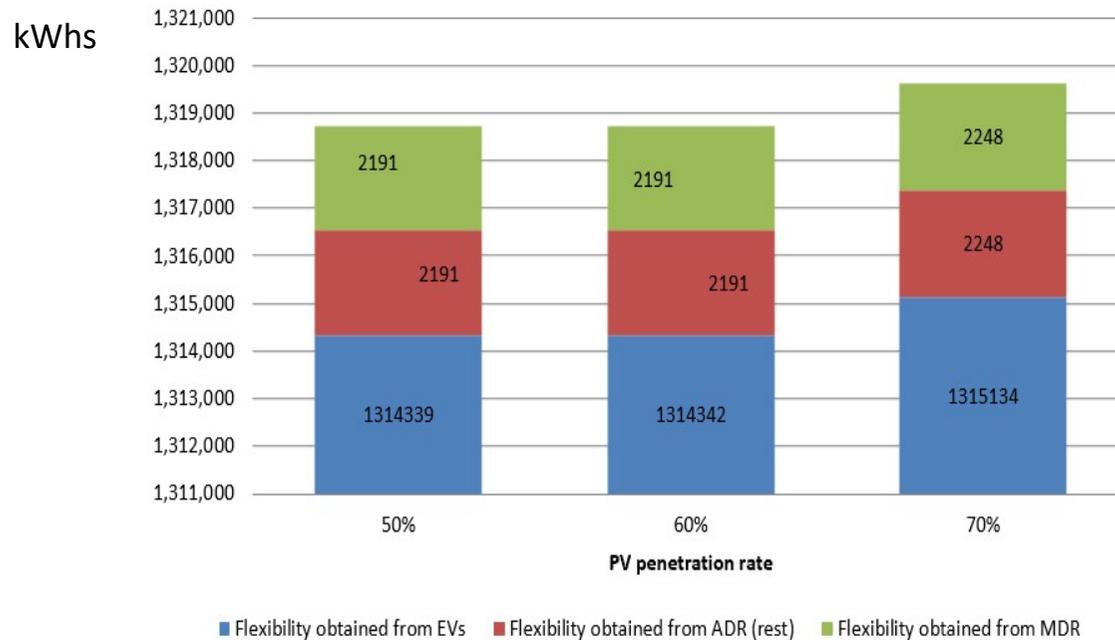


DR is an effective way to reduce the number of outages



A breakdown of the flexibility obtained per member type (EV, rest ADR, MDR)

(EV=30%, PoolSize=30%)



Aggregator's portfolio management policy:

- 1) Obtain max flexibility from EVs
- 2) Remaining flexibility:
 - 50% MDR
 - 50% ADR from non-EV



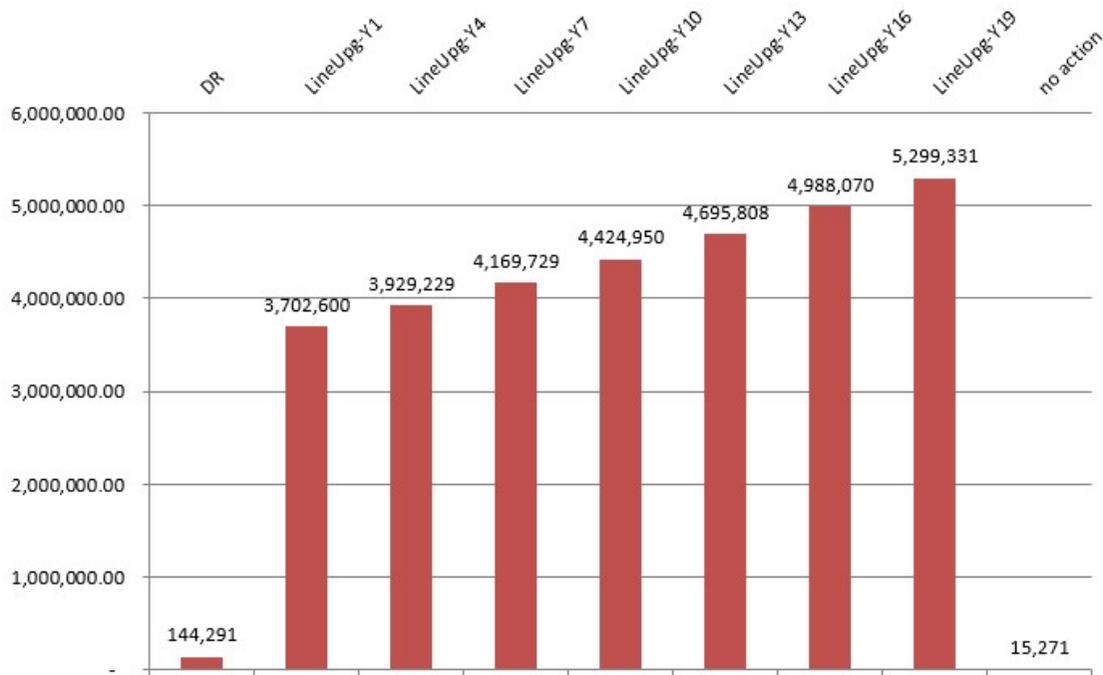
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Attractiveness and Viability of DR

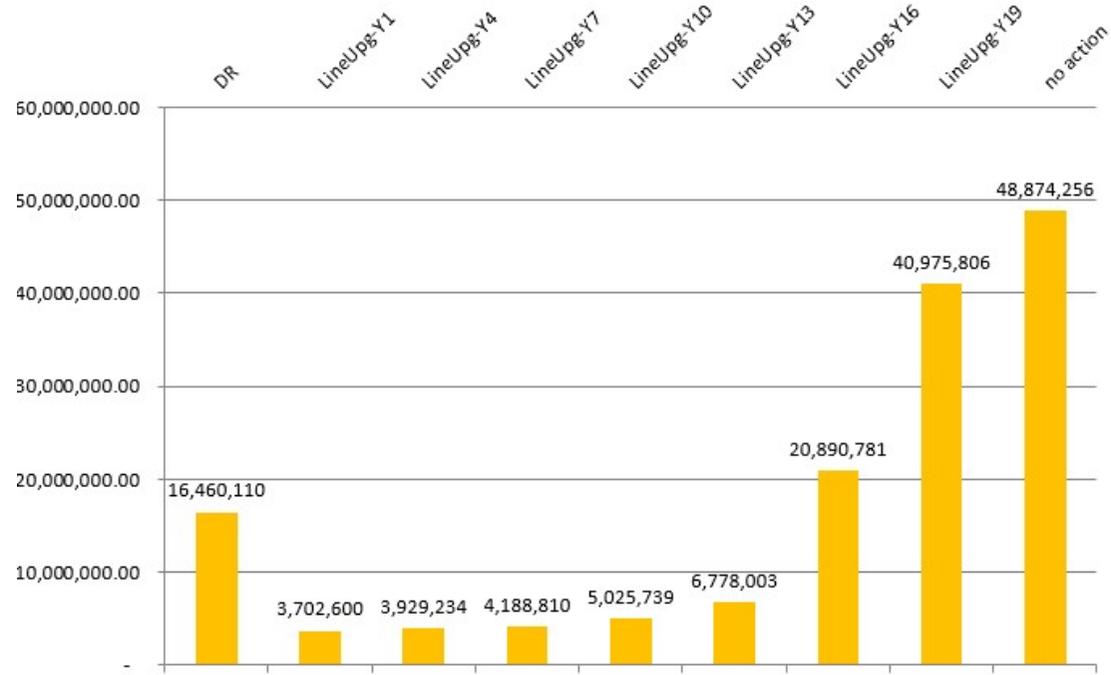


Attractiveness of DR to DSO (compared to alternative options (1/2))

**DSO costs at Year 20 (DR, penalties, lines upgrade)
(LOW penetration rates)**



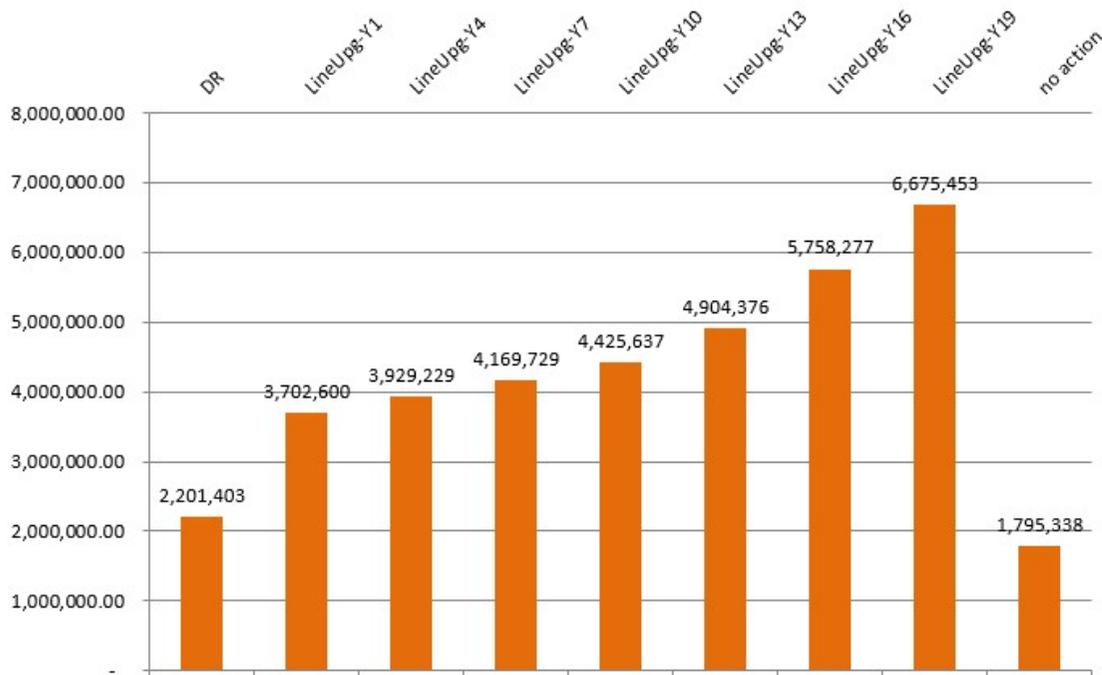
**DSO costs at Year 20 (DR, penalties, lines upgrade)
(HIGH penetration rates)**





Attractiveness of DR to DSO (compared to alternative options (2/2))

DSO costs at Year 20 (DR, penalties, lines upgrade)
(MODERATE penetration rates)



- The MODERATE scenario is the only favourable case for the congestion avoidance Aggregators' service
 - Frequent outages will have a detrimental effect on the society
 - Penalties are 81.6% compared to the costs for flexibility (second-best option)



Viability of Aggregator's service

• Main Assumptions

- 3 scenarios for CAPEX & OPEX

| in € '000 | CAPEX | OPEX |
|-----------|-------|------|
| LOW | 10 | 40 |
| MODERATE | | 80 |
| HIGH | | 120 |

- Average compensation asked from DSO:
 - ADR (EV): € 0.1/kwh
 - Rest members: € 0.26/kwh
- Aggregator distributes 40% of DR compensation to participants
- Aggregator's market share: 30%

| | | EV, PV increase rates | | |
|----------------------------------|----------|-----------------------|-------------|-------------|
| | | LOW | MODERATE | HIGH |
| Aggregator cumulative cash flows | LOW | (900,098) | 167,402 | 5,319,059 |
| | MODERATE | (1,871,993) | (804,493) | 4,347,164 |
| | HIGH | (3,815,783) | (2,748,283) | (2,748,283) |

| | | EV, PV increase rates | | |
|----------------|----------|-----------------------|----------|------|
| | | LOW | MODERATE | HIGH |
| Aggregator IRR | LOW | #N/A | 0% | 24% |
| | MODERATE | #N/A | #N/A | 15% |
| | HIGH | #N/A | #N/A | #N/A |



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Conclusions

- Technical1: congestion issues due to high loads will be important in the near future
 - But RPF are not expected to be a problem in feeder loops
- Technical2: We observe that Demand Side management techniques can greatly reduce power interruptions
- Business1: DR is the most cost effective solution for DSOs when dealing with congestion issues in the MODERATE scenario regarding EV, PV increase rates
- Business2: DR is win-win for LOW costs & MODERATE increase rates scenario



Any questions?

Thank you!



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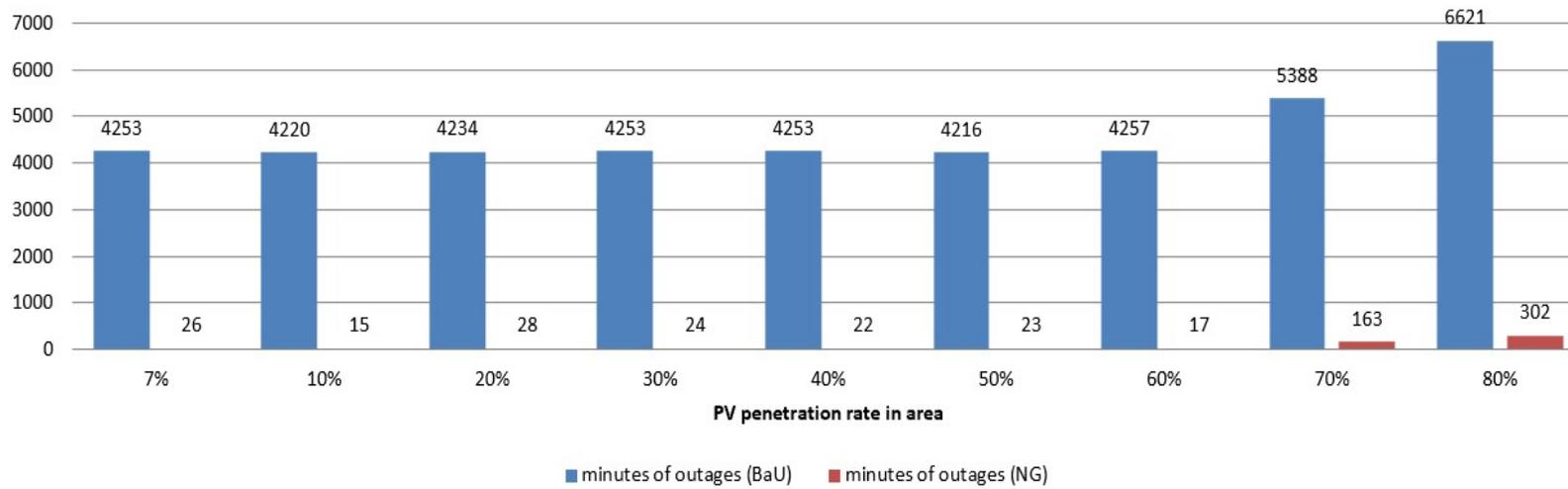


STEcon LV/MV feeder Simulator (additional features)

- User preferences
 - Sensitivity to reward
 - Availability hours (for MDR/ dynamic prices)
- Technical parameters
 - Consumption
 - Production
 - Country irradiation
 - PV size
 - (EV) Battery capacity
 - (EV) Battery availability



Minutes of outages per year (BaU vs with DR) (EV=20%, PoolSize=30%)





Cumulative Cash Flow for Aggregator MODERATE rate scenario, LOW costs

