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2010 Symposium on Microgrids

Benefits of smart DER integration

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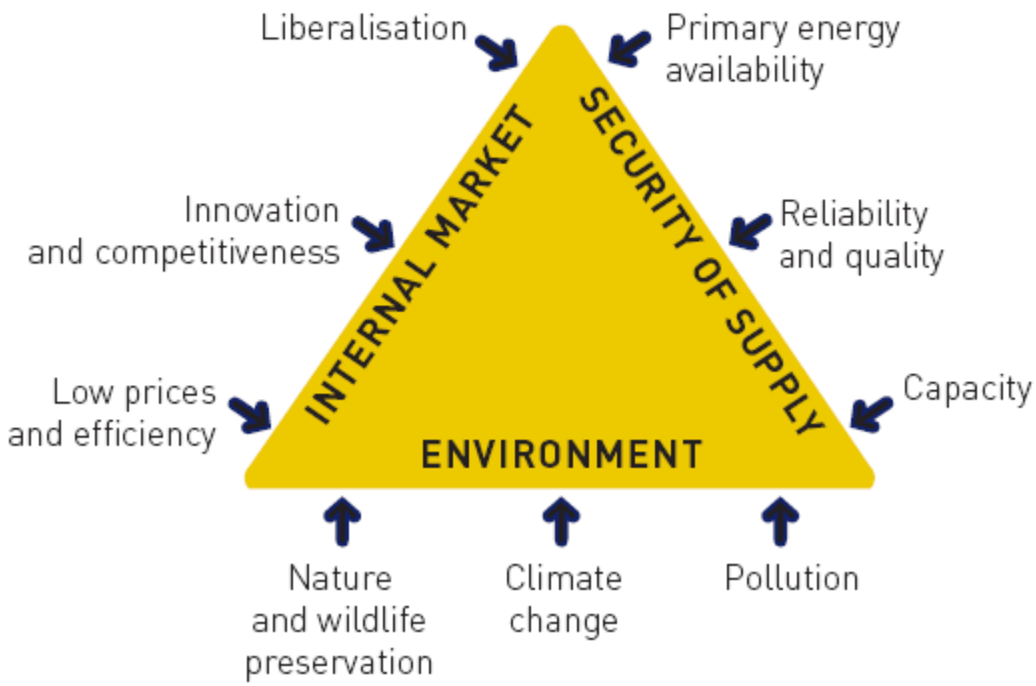
Contents

- Introduction
- Large-scale grid planning models
- Integration of distributed generation
- Charging of plug-in electric vehicles
- Policy recommendations

Introduction: The EU framework

- European Union (EU) energy policy based on:
  - Promotion of renewable energy
  - Increasing energy efficiency
  - Improving security and quality of supply



Distributed generation (DG)

- Increasing DG penetration levels in EU due to RES/CHP support mechanisms, i.e**. feed-in tariffs**
- Significant DG penetration levels may have a great impact on distribution network operation and planning: voltage profile, losses, investment in new infrastructure, etc.
- **Quantification of the impact of DG on distribution costs: investment, maintenance and energy losses**
- Two grid paradigms:
  - **Business as usual (BAU)**: passive distribution grids
  - **Active network management (ANM)**: **smart grids** including generation control and demand response

Plug-in electric vehicles (EV)

- **EV as new DER**
  - Charging loads and charging periods => New challenge
  - Vehicle to Grid (V2G) => New opportunities
- Impacts on **network infrastructure**
  - Are existing networks capable to feed the expected consumption?
  - Will distribution energy losses increase significantly?
- Generation mix and system operation
  - Could EV (V2G) provide storage capability and ancillary services to improve system operation?
  - Could the system be operated with a higher proportion of renewable and intermittent sources?

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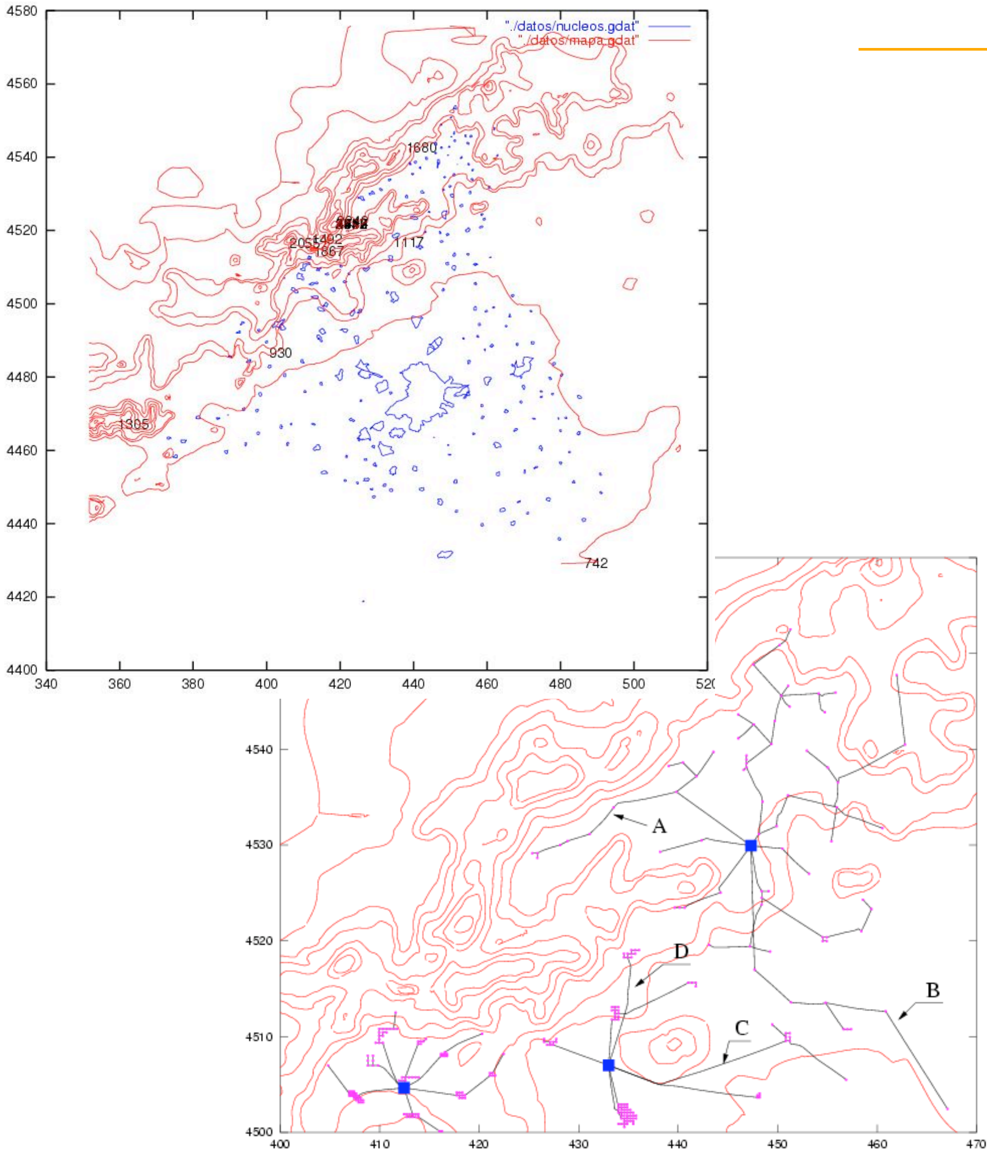
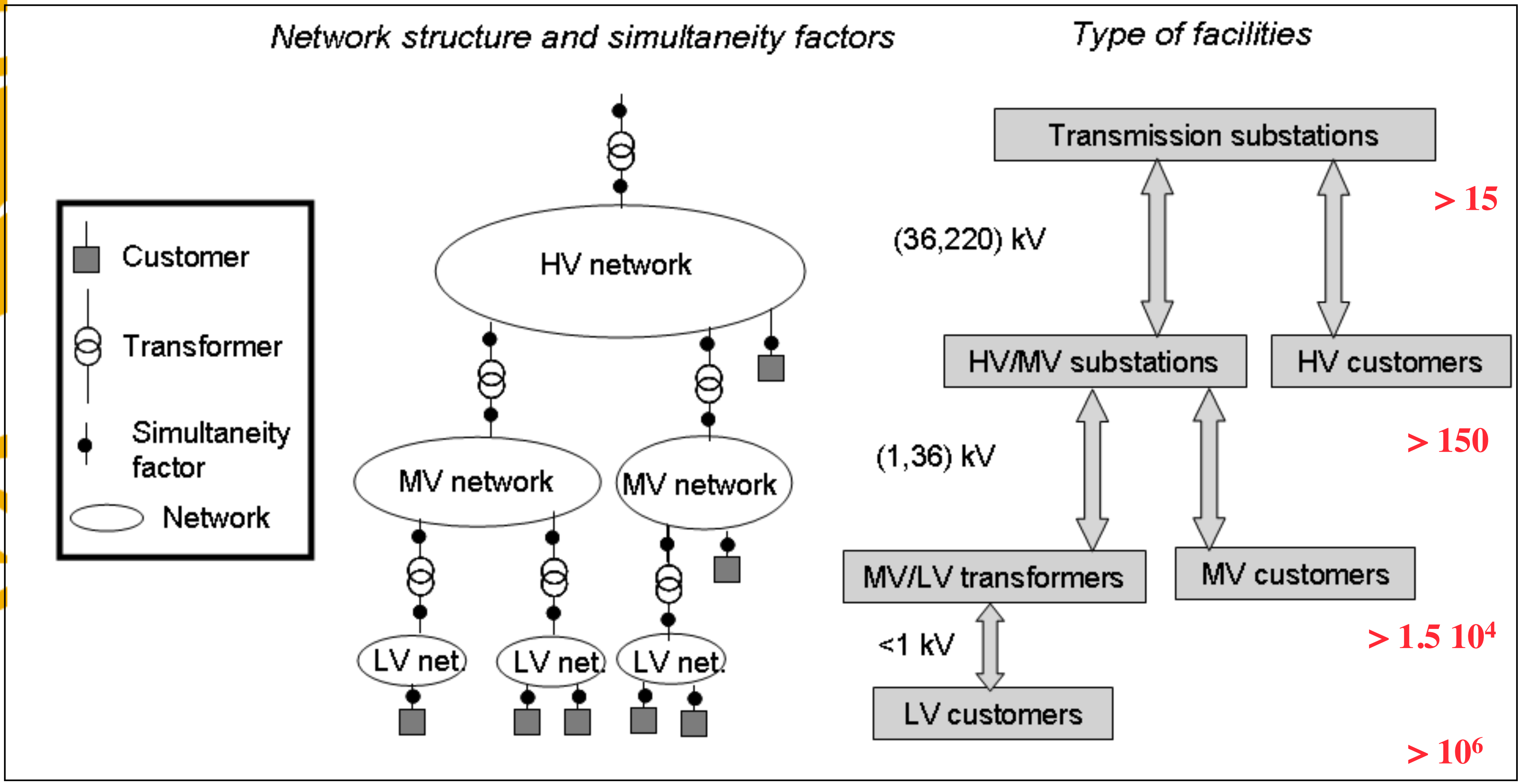
Cost Assessment: Large-scale grid planning models



Main Features

- *Large scale (> 1 million customers)*
- *Both urban & rural areas*
- *Detailed Geographical Features:*
  - *Settlements identification*
  - *Automatic street map building*
  - *Forbidden ways through*
  - *Aerial/underground areas*
- *Voltage, capacity & reliability constraints*
- *Detailed standardized equipment and parameter library*
- *Detailed reliability assessment*

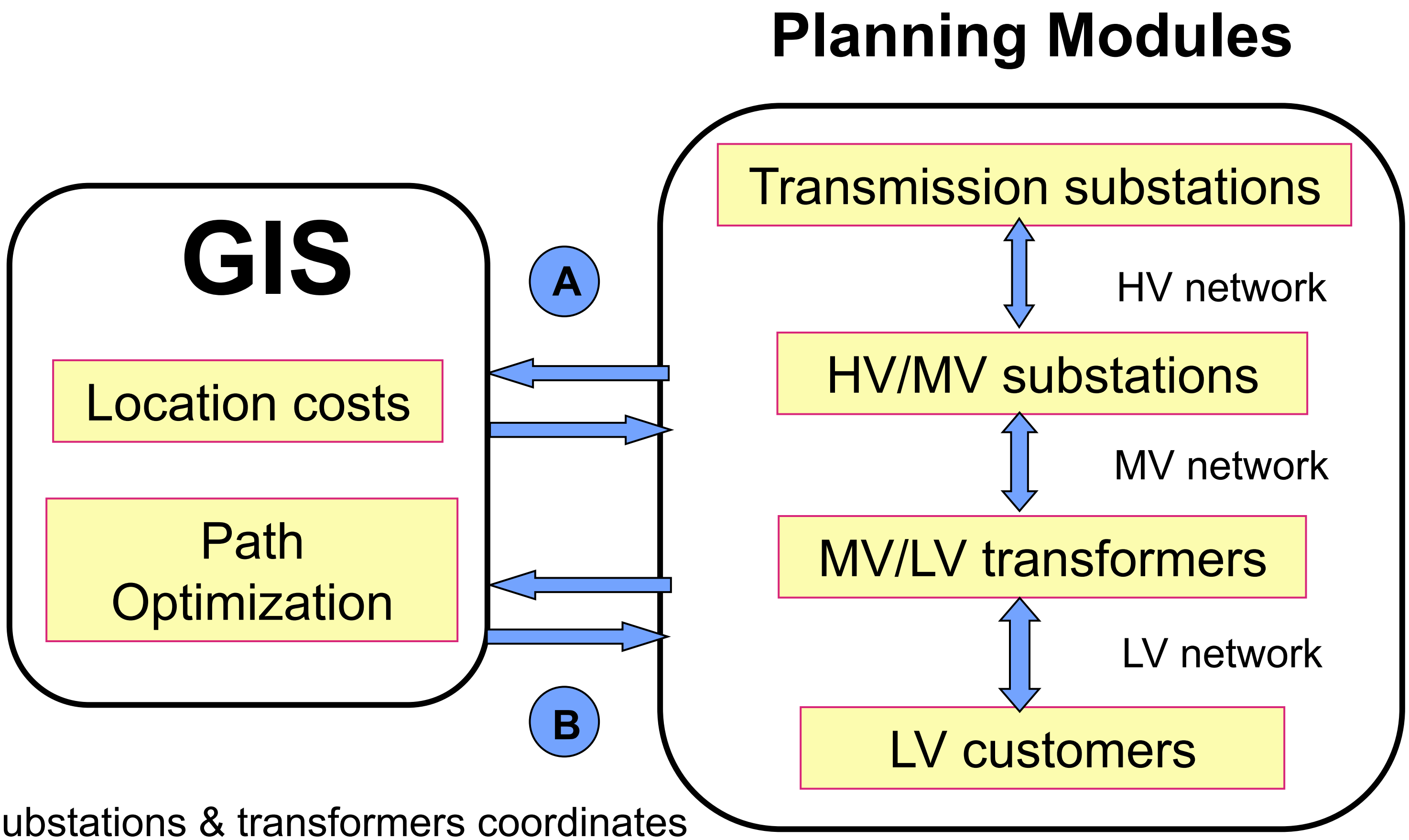
Large-scale planning: scope



• *Input Data: HV, MV and LV customers, and transmission substations*

•*Results of the model: LV, MV & HV network, HV/MV and MV/LV substations*

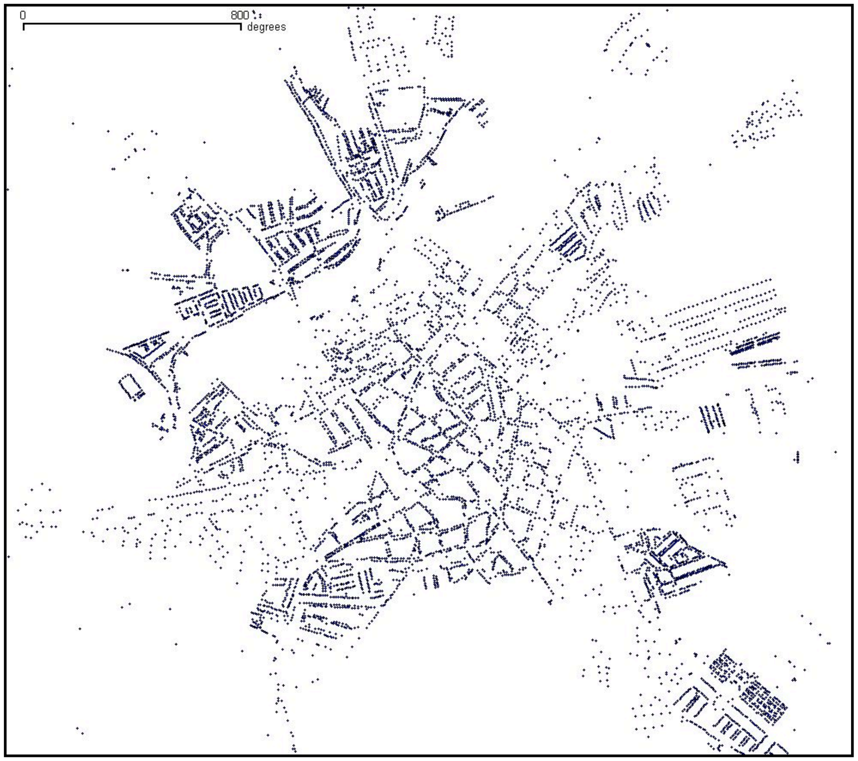
Geographical constraints



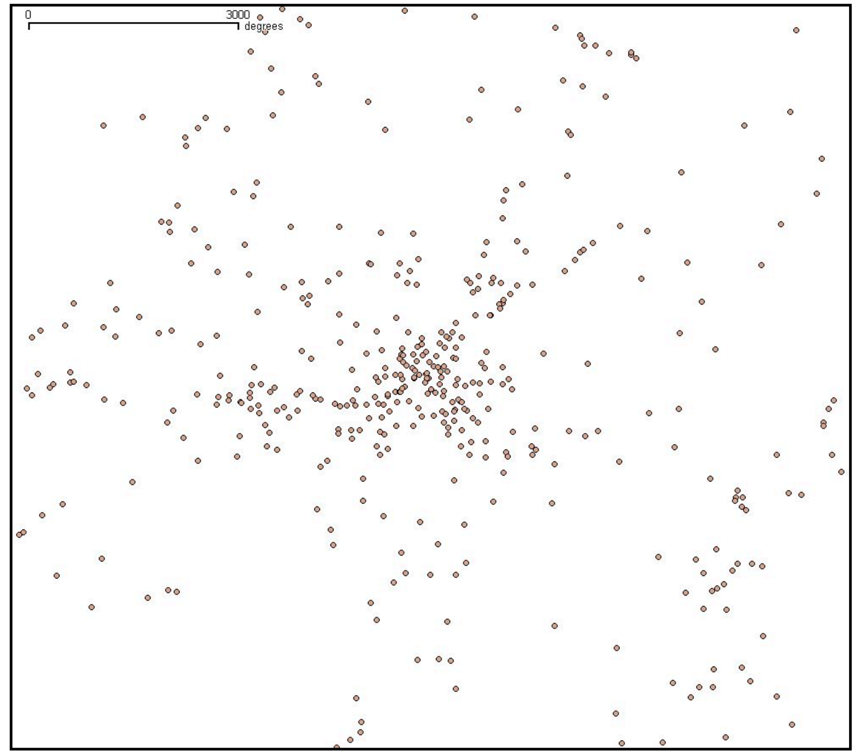
A Substations & transformers coordinates

B Lines & cables ends

LV networks in Spain



Location of LV customers

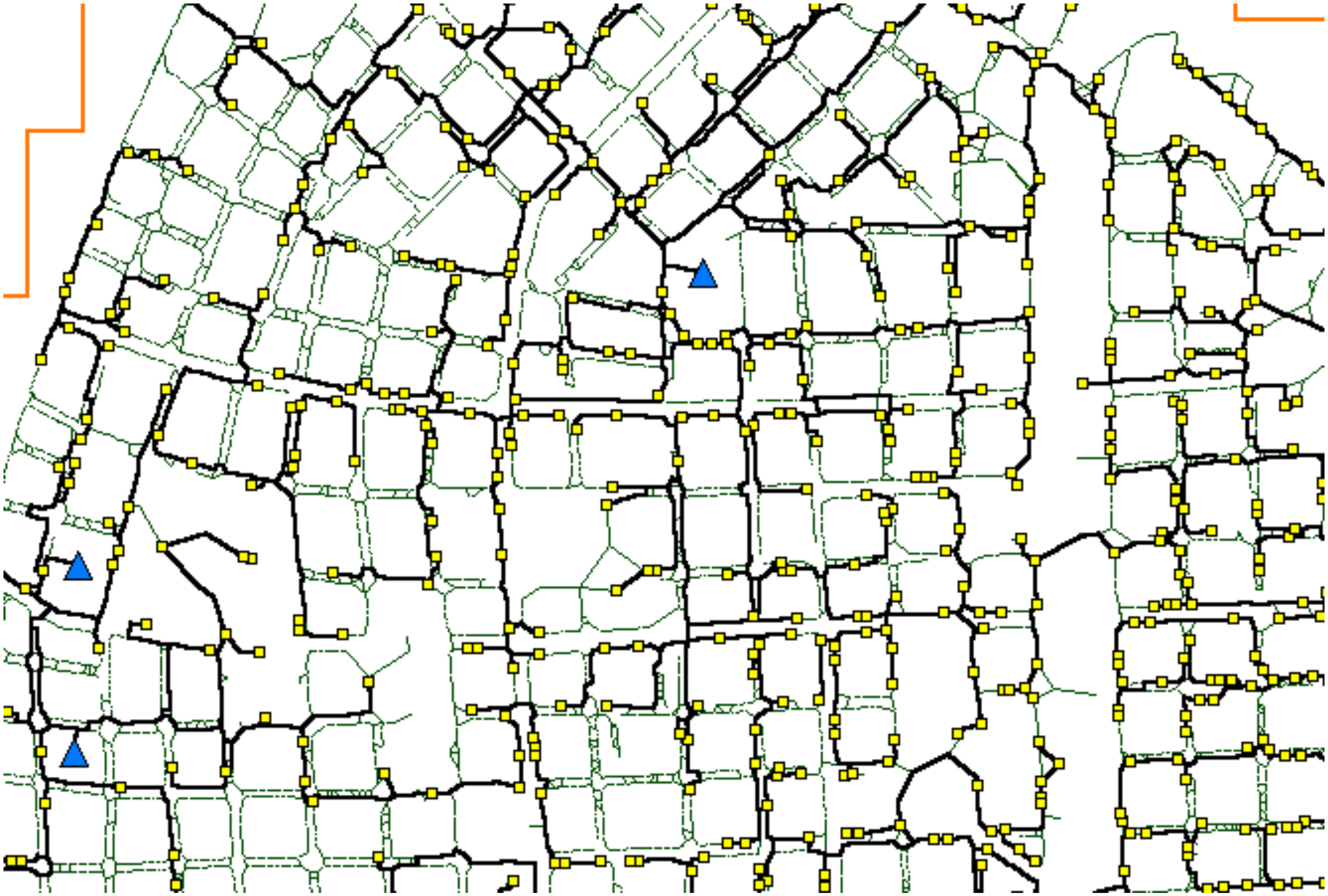


Location of MV/LV transformers

LV networks in Spain

An urban MV network

Street map built by the model. Note the crossings in the large avenues



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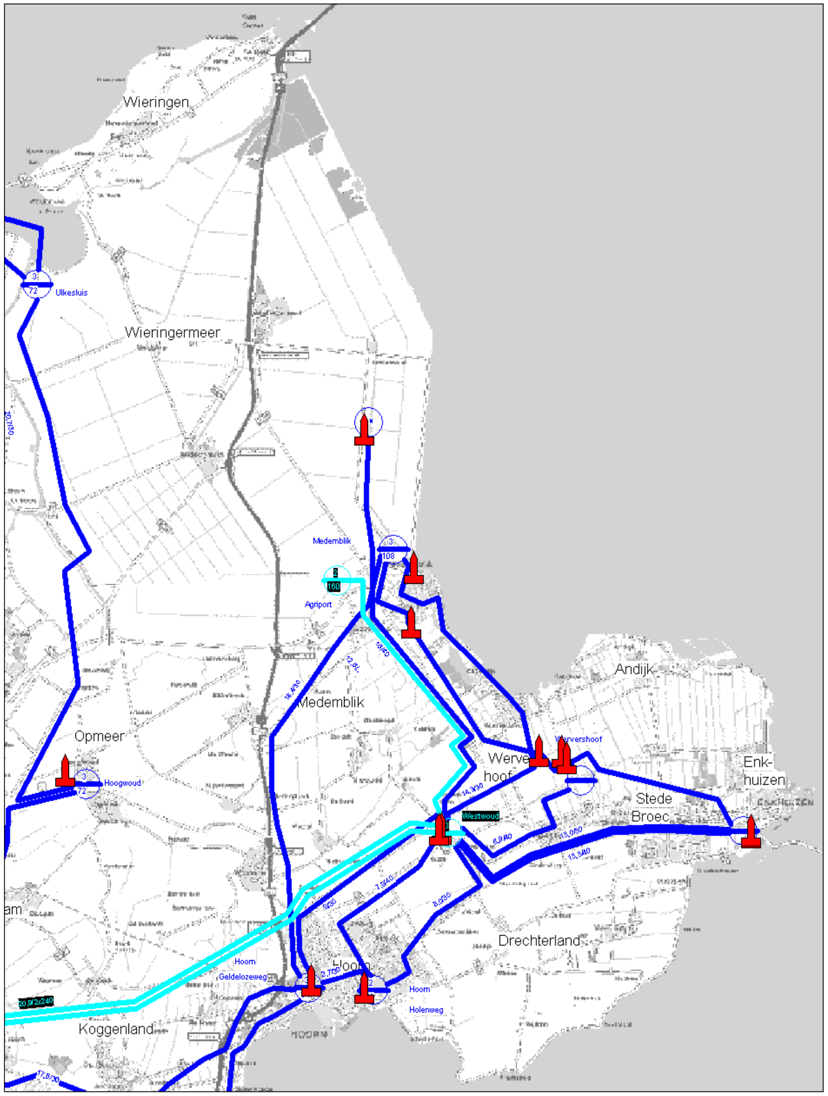
Distribution areas: Kop van Noord, The Netherlands



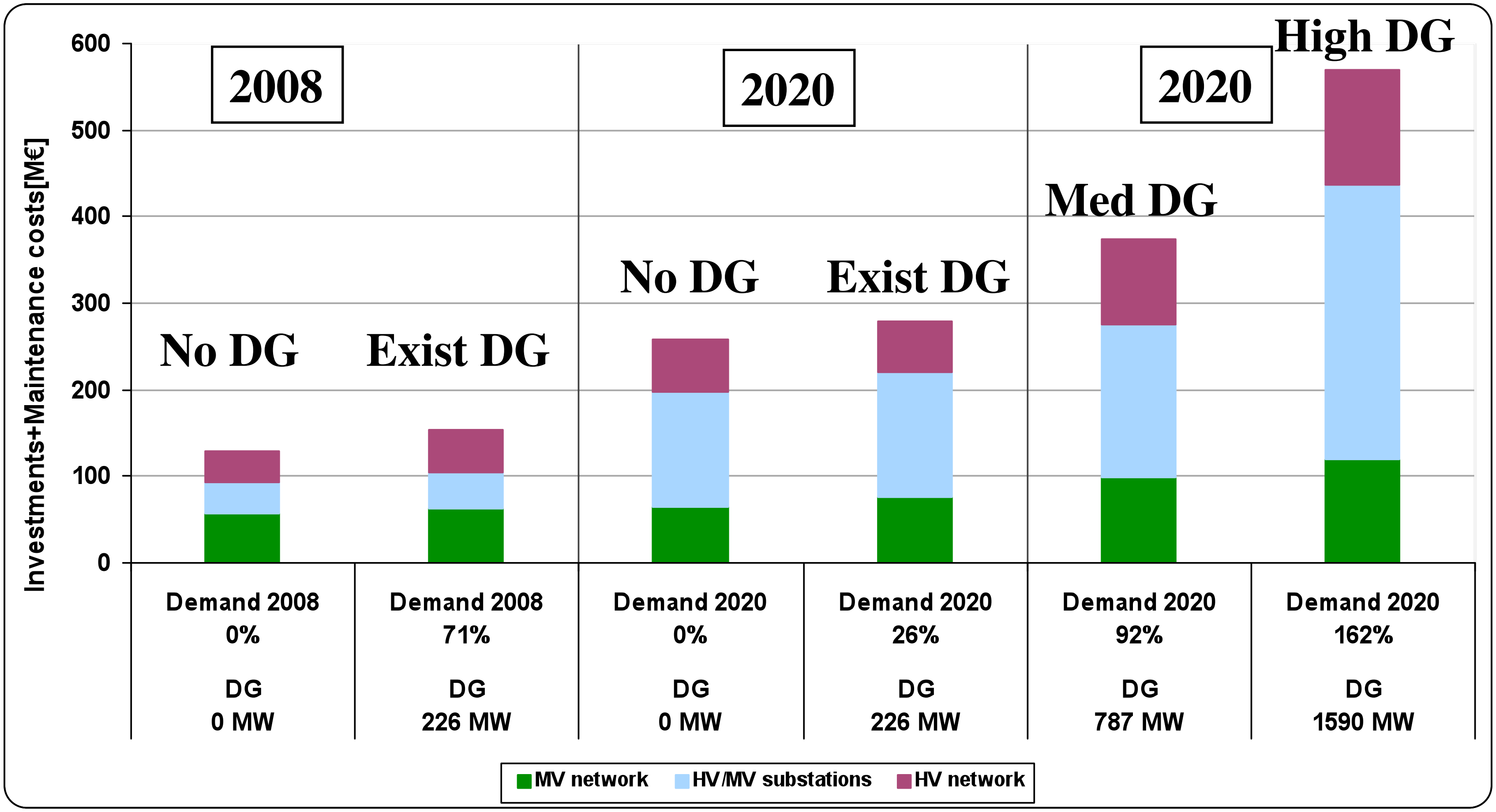
- Rural/sub-urban area
- Approx. 80000 loads (~675 km²)
- Grid: HV (150kV-50kV) and MV (10kV)
- LV loads aggregated at MV points
- Present DG already high in relation to local demand
- Major developments expected in DG (especially at MV):
  - Attractive area for further growth of wind energy
  - Mayor developments in agriculture: CHP for horticultural greenhouses

Assessment approach

- Scenario: location and size of loads and DG in the planning year
- For each distribution area, 8 scenarios were considered:
  - Two levels of demand: 2008 and 2020
  - Four DG levels: no-DG, 2008, 2020-medium and 2020-high
- Snapshot: different simultaneous consumption and production in a given scenario. A scenario comprises two snapshots:
  - **Peak net demand**
  - **Peak net generation**
- Both snapshots may have an impact on total system costs

BAU Results

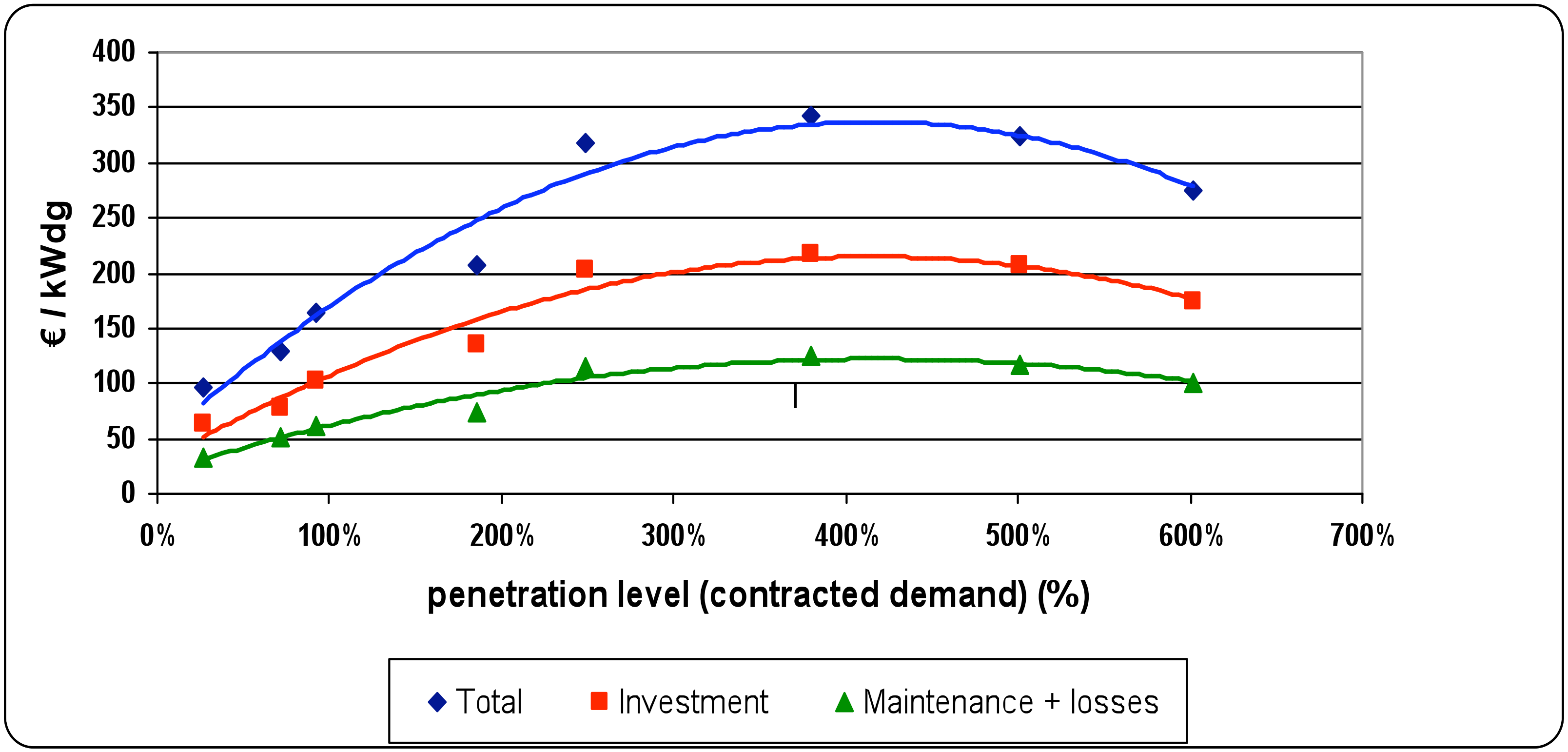
- The Netherlands: Kop van Noord



Present value of investment and maintenance costs

BAU Results

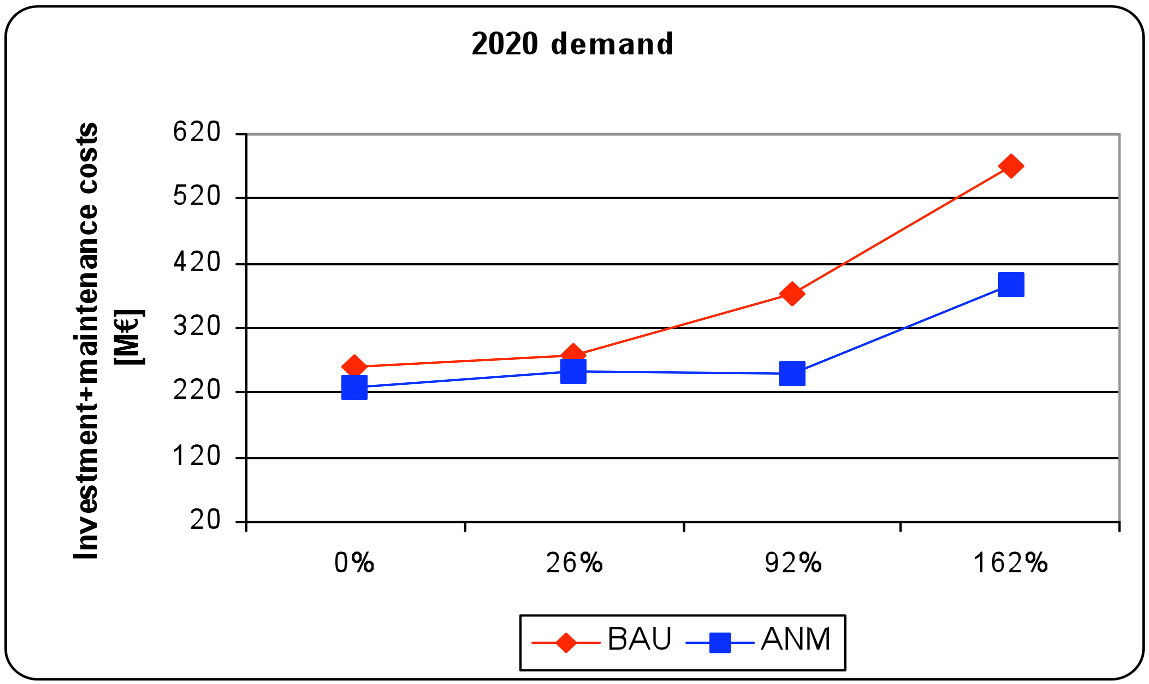
- The Netherlands: Kop van Noord



Incremental costs per installed kW of DG
(compared to the no-DG scenario with the same demand)

ANM vs BAU: cost savings

- The Netherlands: Kop van Noord
- ANM: shifting lighting demand of greenhouses, limited wind curtailment and controlling CHP production. Main savings correspond to transformation capacity due to a reduction in maximum DG production.



Findings

- DG capacity is expected to continue increasing in EU
- **Low DG penetration** levels do not increase distribution costs, but **high DG penetration** levels yes
  - In areas with 162% of DG penetration, costs increase by 125%
- DG integration costs can be reduced through **Active Network Management (ANM) and microgrids**
  - savings from 2% to 35% as compared to BAU
- Results significantly differ on an area basis. Savings highly depend on:
  - **Demand response and DG controllability**

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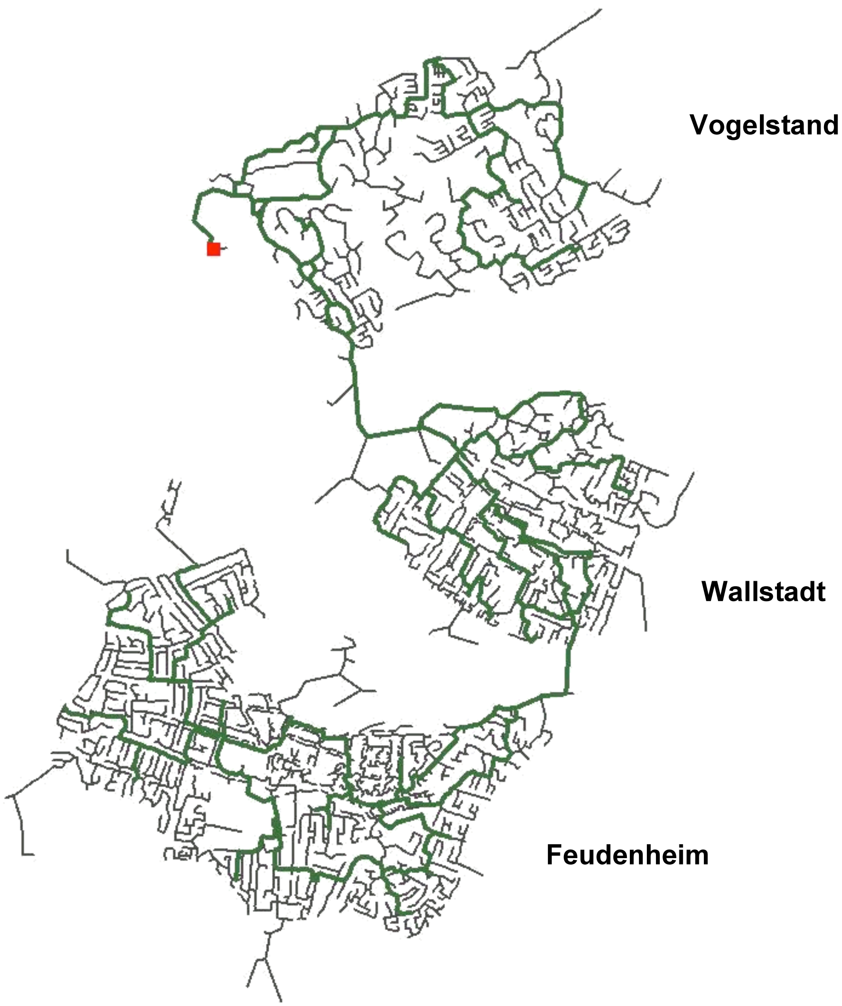
Case studies (i)

- MV & LV distribution network in the urban area (A)

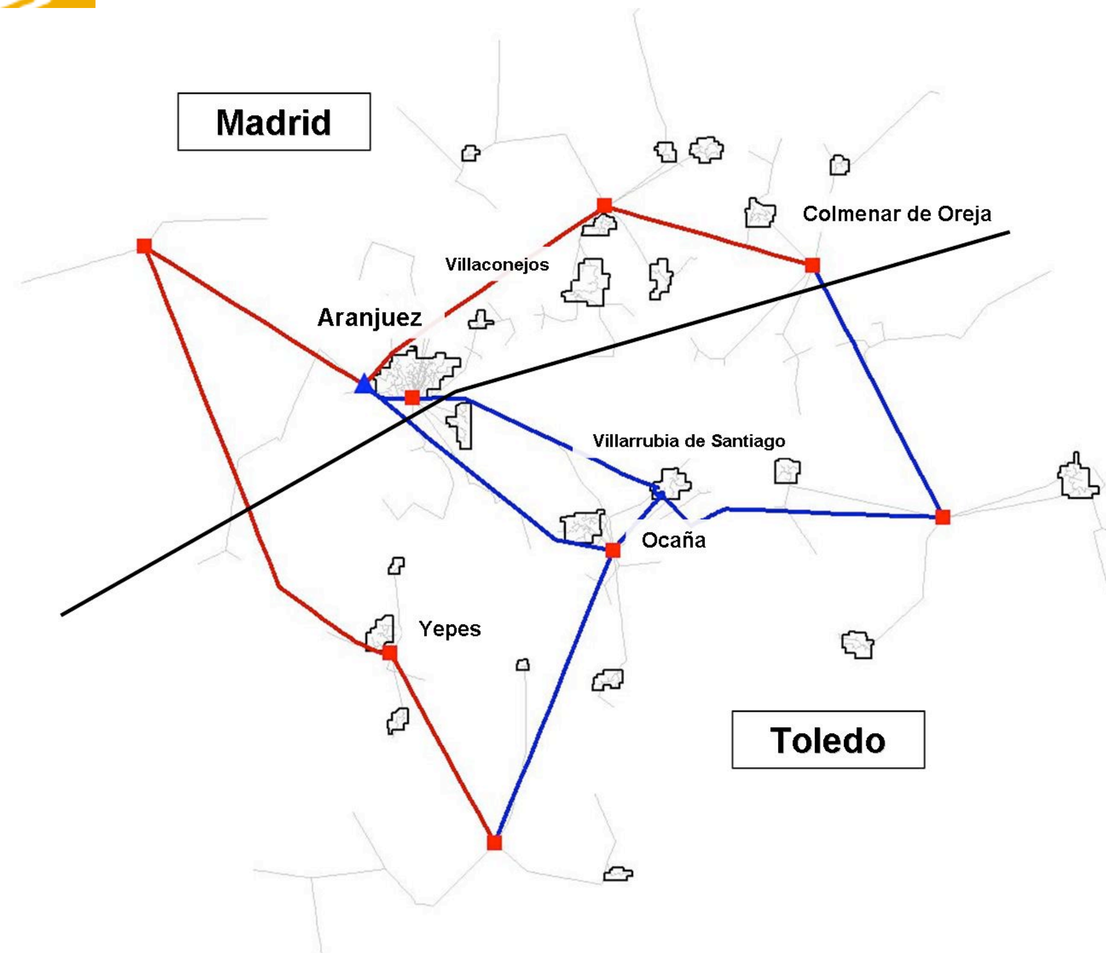


Area (km2)	**20**
Population	**36,238**
Cars	**3,676**
LV supply points	**6,121**
LV load (MW)	**34**
MV supply points	**15**
MV load (MW)	**38**

MV/LV substation
MV cables
LV cables

Cases studies (ii)

- HV, MV & LV distribution networks in the industrial and residential area (B)



Area (km2)	3,400
Population	52,224
Cars	28,626
LV supply points	61,304
LV load (MW)	282.3
MV supply points	268
MV load (MW)	112.7

HV substations
132 kV lines
45 kV lines
HV/MV substations
MV lines

Charge of PHEV & BEV

	PHEV 30 (MIT)	PHEV 40 (USABC)	PHEV 60 (EPRI)	BEV (200 MI Range) (MIT)
Peak power [kW]	44	46	99	80
Energy capacity [kWh]	8	17	18	48
Charge power at 0.2C [kW]	1.6	3.4	3.6	9.6
Charge power at 1C [kW]	8	17	18	48
Charge power at 2C [kW]	16	34	36	96

Notes:
0.2C: normal charge: To reach the full storage capacity it takes 5 hours
1C: rapid charge. To reach the full storage capacity it takes 1 hour
2C: ultra-rapid charge. To reach the full storage capacity it takes 30 minutes

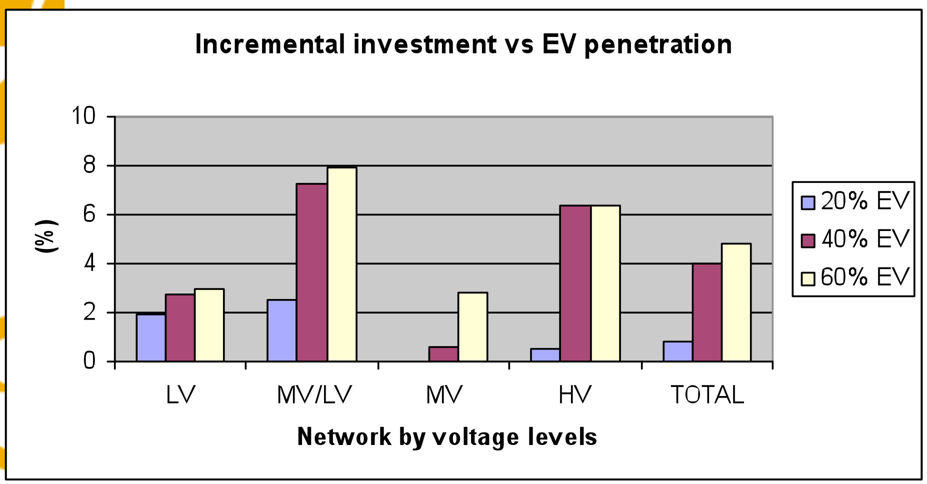
EV connection and operating modes

Scenarios	% of EV
2020	35
2030	51
2050	62

Off-peak hours (0:00-6:00)	85% of total EV are connected	•95% normal charge • 5% fast charge
Peak hours (16:00-21:00)	40% of total EV are connected	•65% normal charge •35% fast charge • 5% power to grid

Investments in the industrial and rural area (B)

- **Network requirements in peak hours vs increasing the level of penetration of EV**



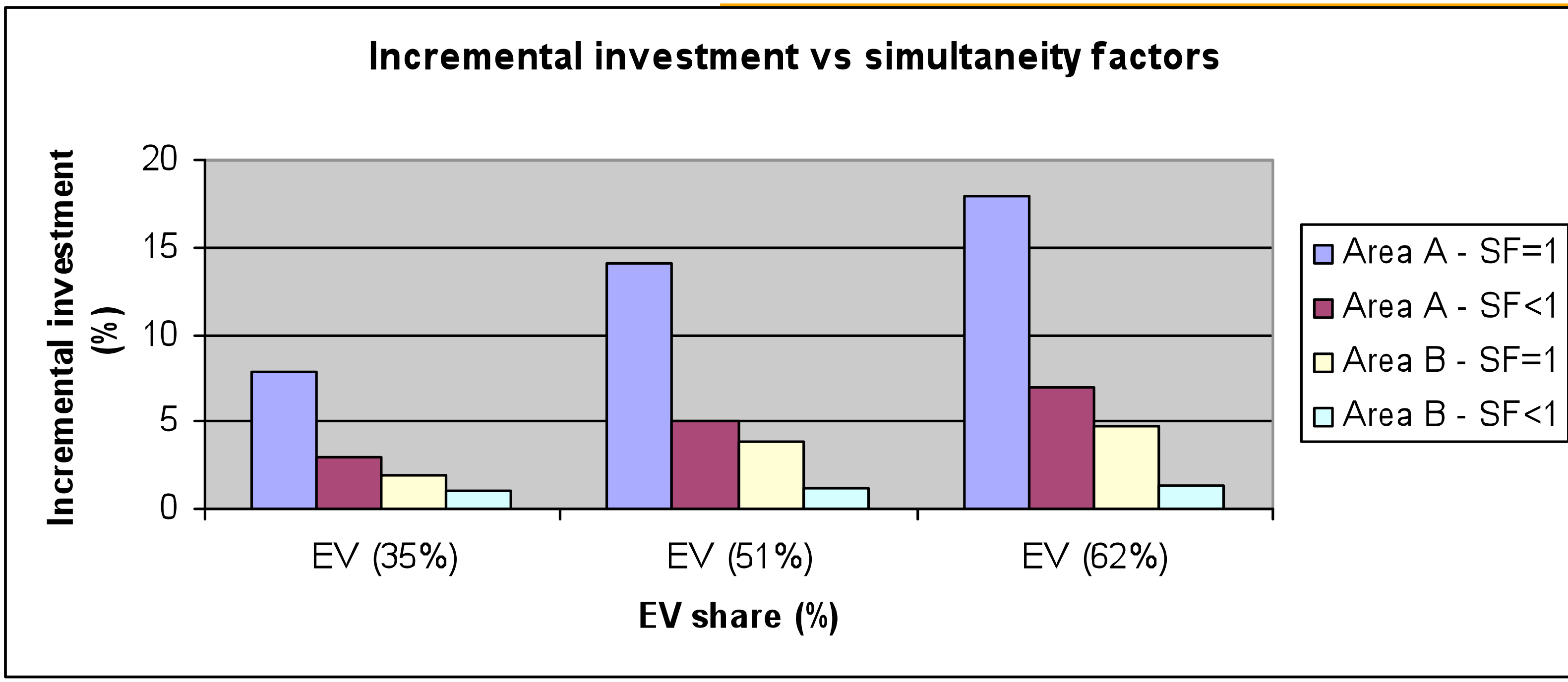
Total cars	28,626
Load connection points	61,572
Contracted demand (MW)	395
EV cars (60%)	17,500
EV connected at peak	7,000
EV connected demand (MW)	51
Incremental cost (€/EV)	502
Incremental cost (€/kW of EV)	70

Management of charging in peak hours

- Implementing smart strategies to avoid coincidence of charging among EV can decrease the need for network additions

- Assuming 5 hours in the peak period, a new simulation has been done considering the following simultaneity factors
  - Normal charge (4h): SF=0.80
  - Fast charge (0.75 h): SF=0.15
  - Very fast charge (0.33 h): SF=0.07

Impact of charging simultaneity factors on network investment



Two findings:

- Required investment for the same level of EV penetration is higher in area A with high density of population and underground network than in area B
- Charging management decreasing simultaneity factors has a great impact decreasing required investments

Findings

- Network impacts depend on EV penetration levels
- EV impact on network investment
  - Peak hours: increments between 5 and 15% depending on load density. Higher increments in urban districts
  - EV charging strategies decreasing simultaneity factors can save up to 60-70% of the required investment
  - Off-peak hours: no special network requirements detected
- Energy losses could increase up to 40% of actual values in off-peak hours when most of EV would be charged

EU policy recommendations

- Regulated revenue allowances for distribution companies should take into account **incremental costs** due to DG integration and EV charging
- Time of use **cost-reflective tariffs** or hourly prices should be sent to end consumers (loads, generation or both) to provoke efficient responses
- Flat feed-in tariffs should be avoided. They do not **incentive controllable DG** to produce at peak hours
- **Smart grid deployments** would facilitate DER integration achieving system global efficiency

Thank you very much

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