Virtual aggregation in time and space hides critical operational details

EERA ESI PS2 workshop
2016-11-04 @ DTU
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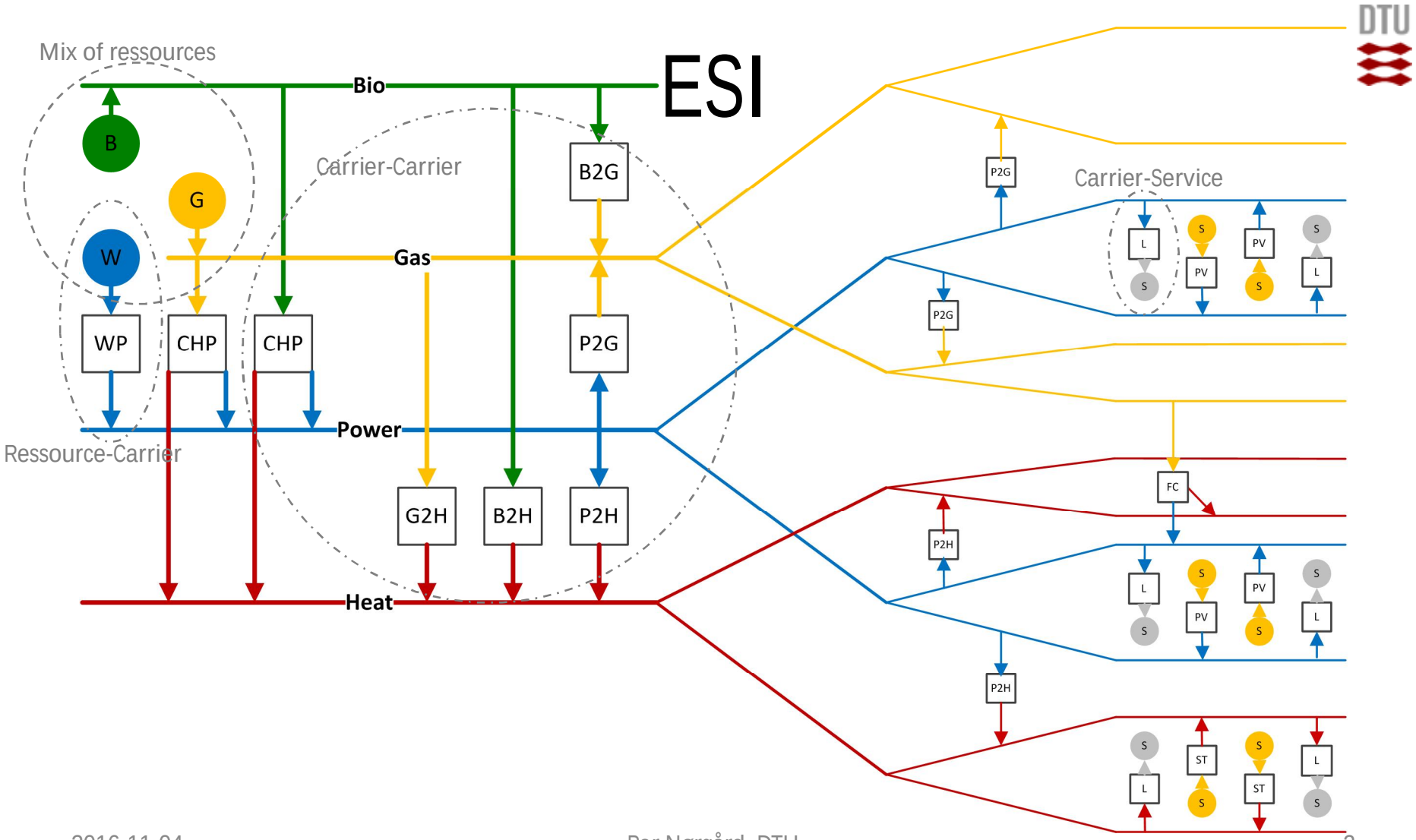

ESI
Mix of ressources
Bio
B
G
W
WP
CHP
CHP
Carrier-Carrier
B2G
Gas
P2G
Power
Ressource-Carrier
G2H
B2H
P2H
Heat
P2G
P2G
Carrier-Service
L
S
S
PV
PV
S
S
L
FC
P2H
P2H
S
ST
S
L
L
S
ST
S

Needs for aggregation

System

- Simulation of one year of a large, complex, integrated energy system:
  - 30 000 000 sec
  - 30 000 000 components
  - 3 000 000 actors
  - 300 markets
  - 3 energy sectors

Aggregation

- Pro:
  - Simplification
- Cons:
  - Simplification

Hidden critical operational properties

Aggregation in time

- Aggregation in time = average over time
- Critical situations in power flow and power balance may be hidden

Aggregation in space

- Aggregation in space = virtual / physical addition of distributed contributions
- Critical bottlenecks in and overloads of the energy infrastructures may be hidden

Example

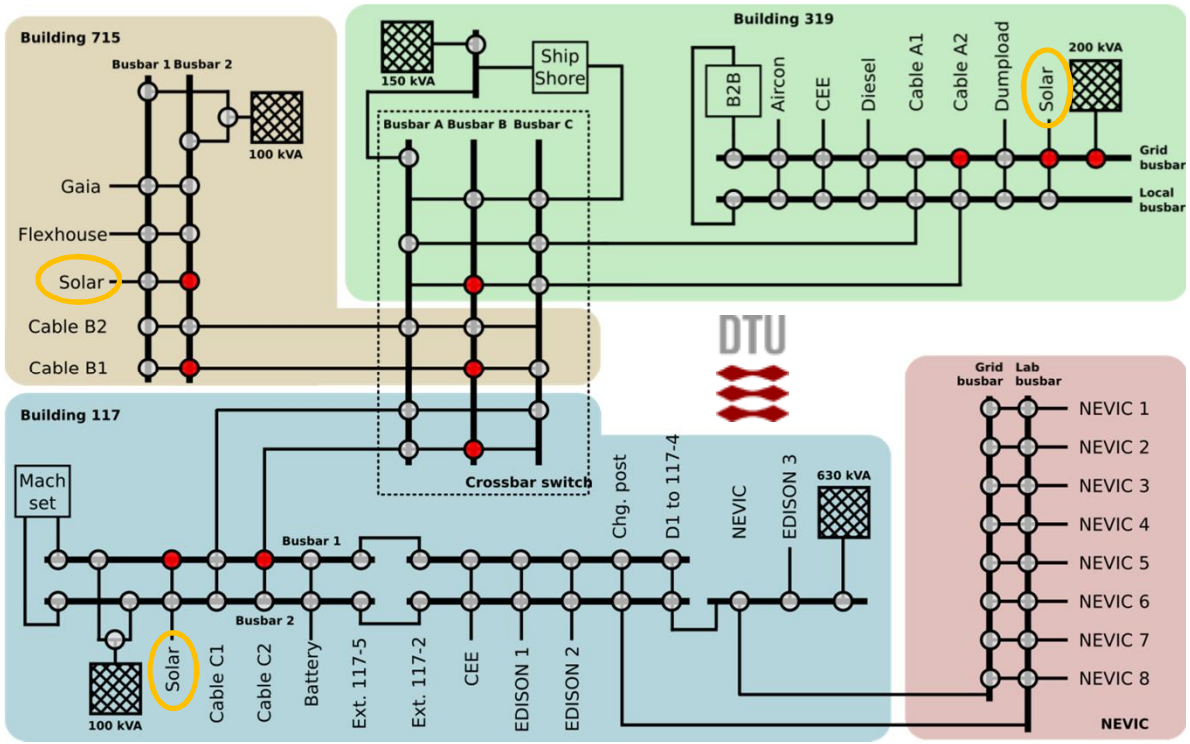
- SYSLAB @ DTU
- 3 x distributed PV panels

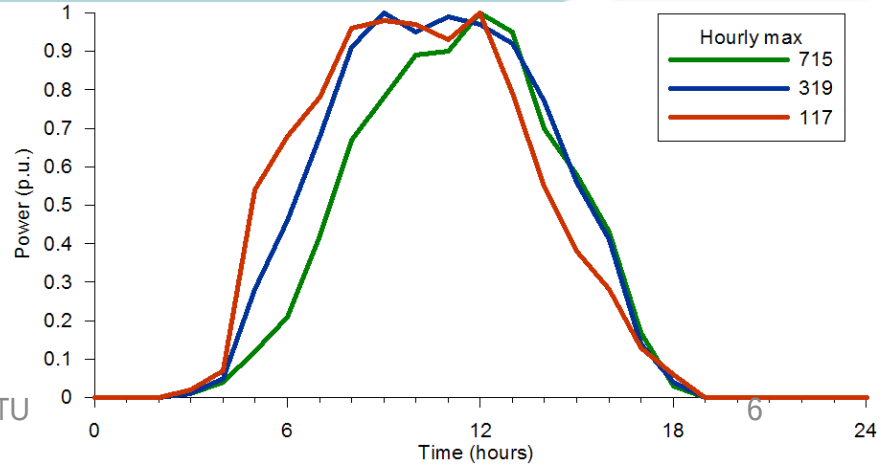
PV 117
5+5 kWp
100° / 20°

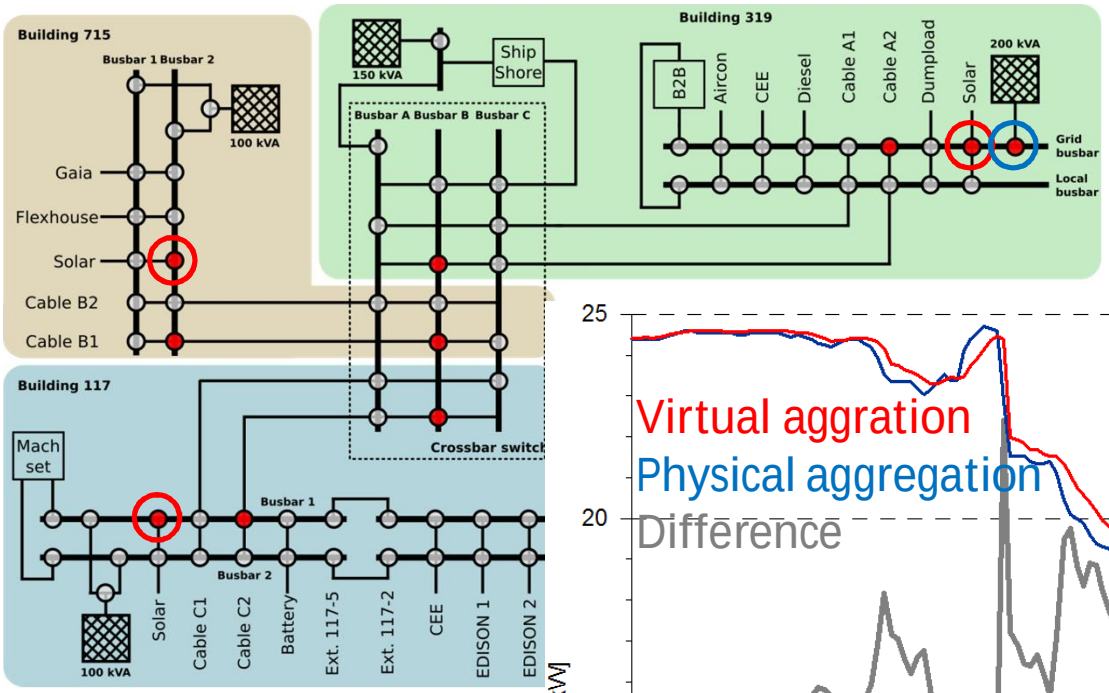
1000 m

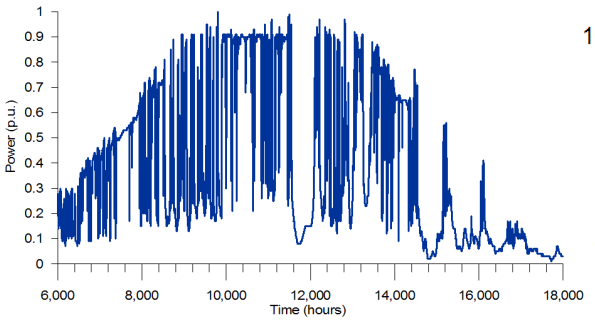
PV 319
5+5 kWp
180° / 40°

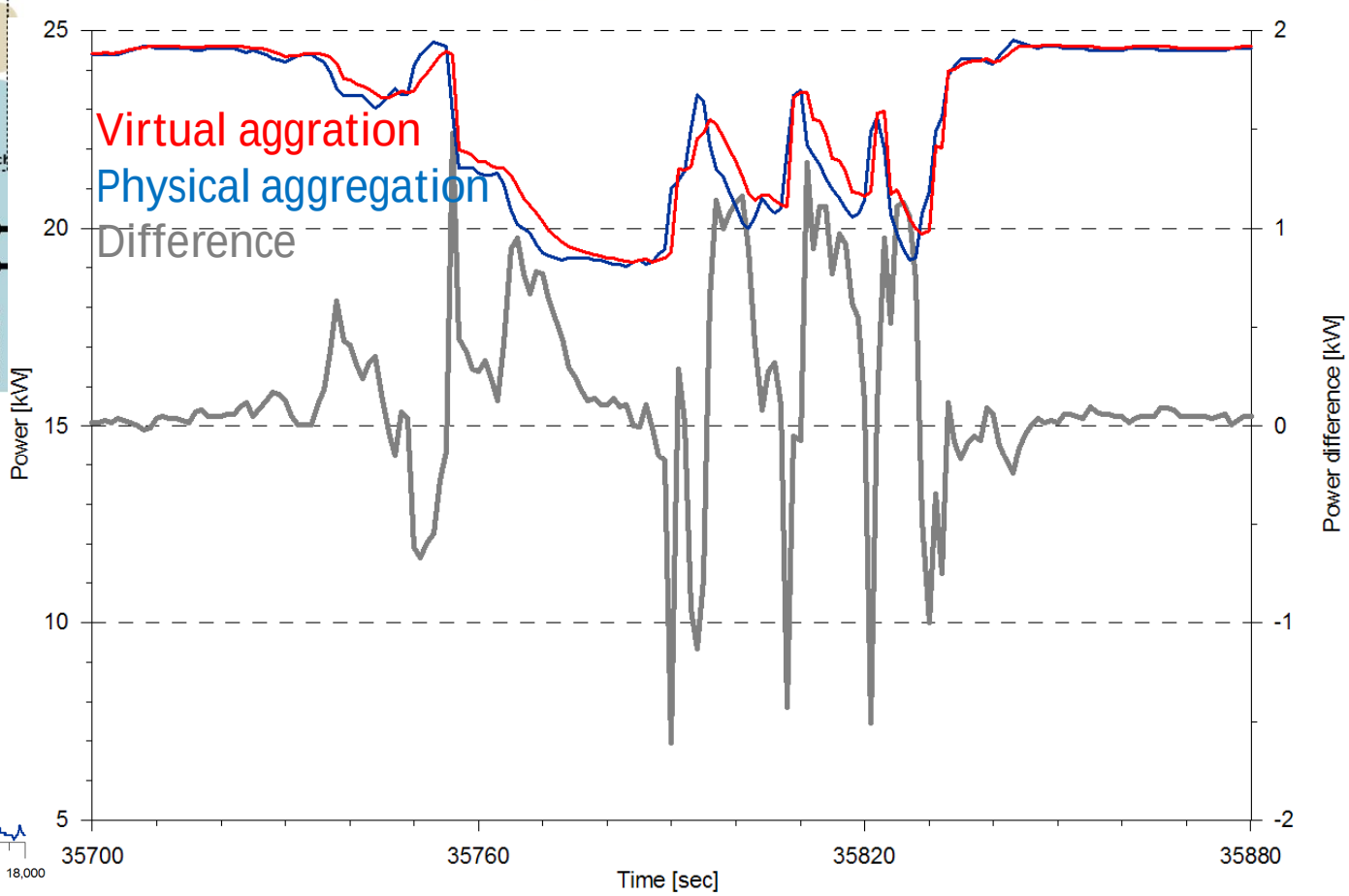
PV 715
5+2 kWp
190° / 60°

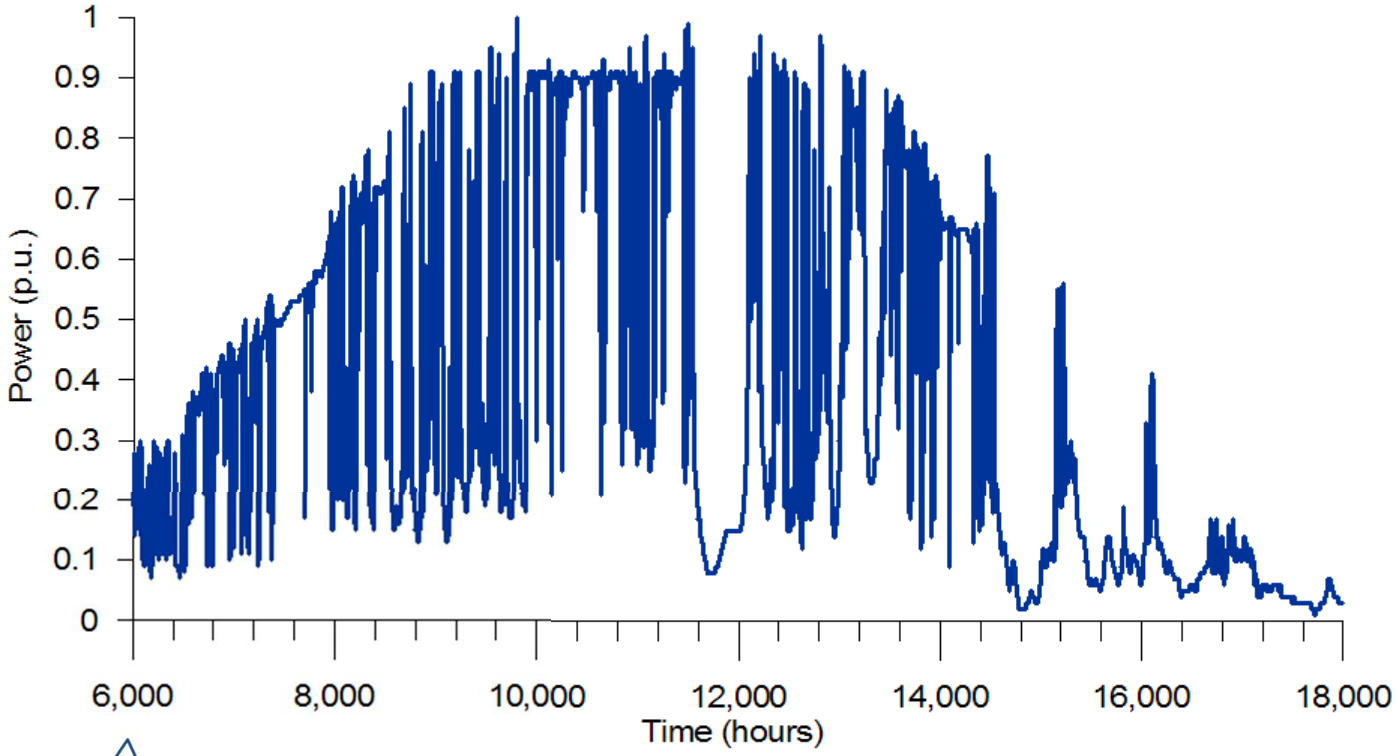


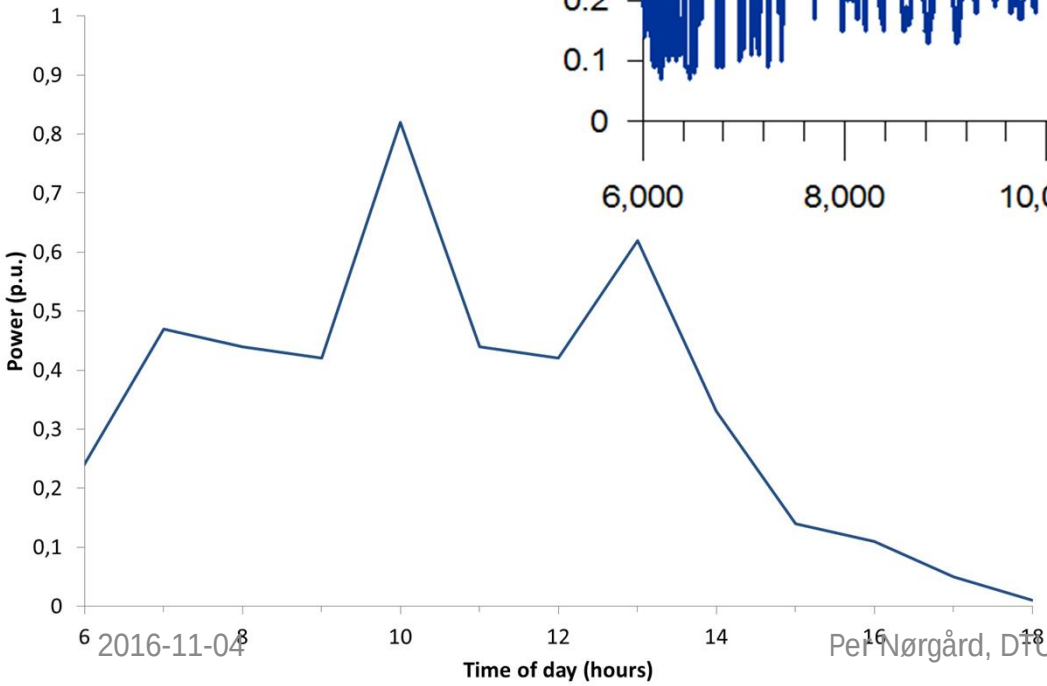


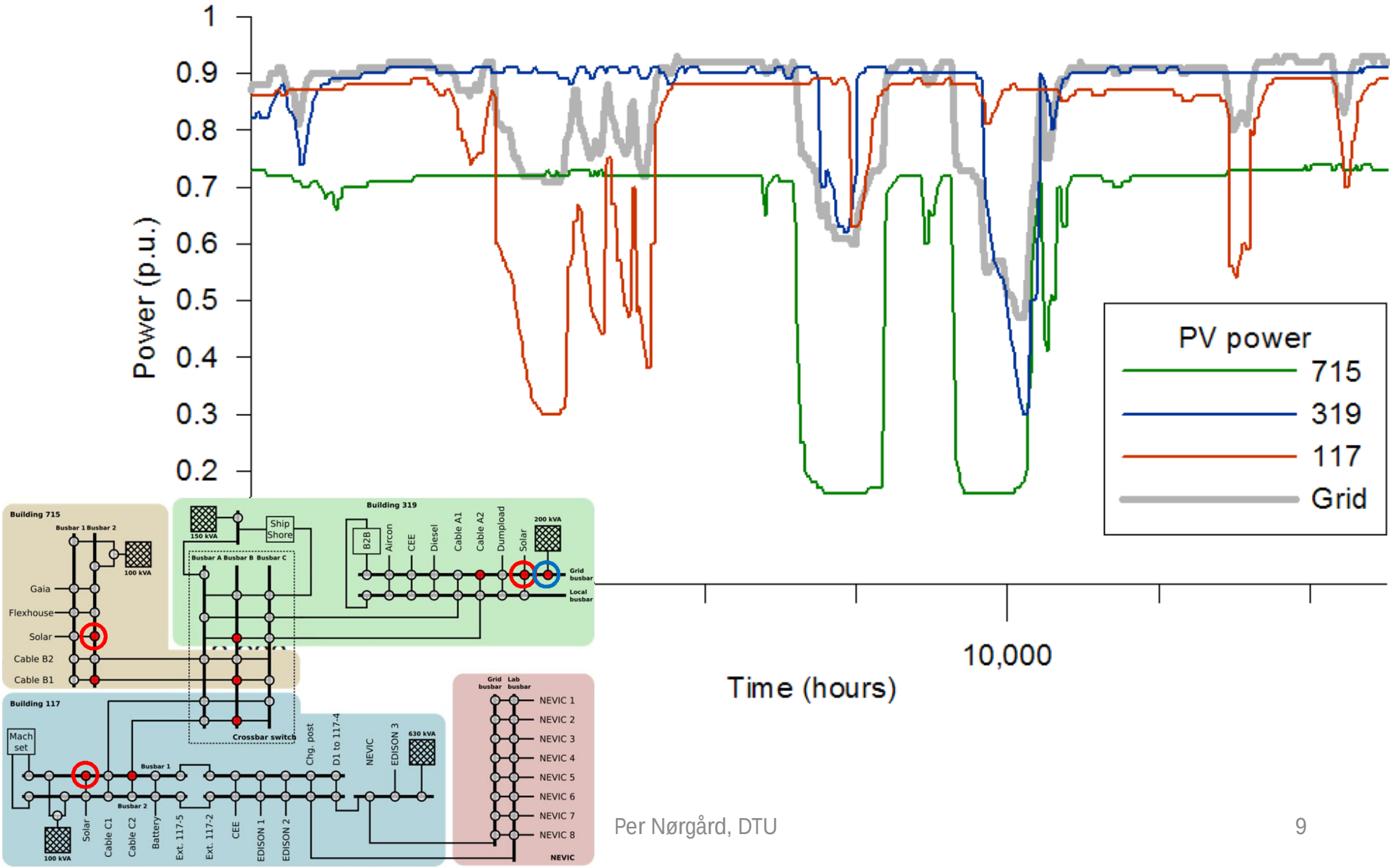

Building 715
Busbar 1 Busbar 2
100 kVA
Gaia
Flexhouse
Solar
Cable B2
Cable B1
Building 319
150 kVA
Ship Shore
Busbar A Busbar B Busbar C
B2B
Aircon
CEE
Diesel
Cable A1
Cable A2
Dumpload
Solar
200 kVA
Grid busbar
Local busbar
Building 117
Mach set
Busbar 1
Busbar 2
100 kVA
Solar
Cable C1
Cable C2
Battery
Ext. 117-5
Ext. 117-2
CEE
EDISON 1
EDISON 2


Power (p.u.)
Time (hours)


Virtual aggration
Physical aggregation
Difference
Power [kW]
Power difference [kW]
Time [sec]


Power (p.u.)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6,000
8,000
10,000
12,000
14,000
16,000
18,000
Time (hours)


Power (p.u.)
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
6
8
10
12
14
16
18
Time of day (hours)


Power (p.u.)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
10,000
Time (hours)
PV power
715
319
117
Grid
Building 715
Busbar 1 Busbar 2
100 kVA
Gaia
Flexhouse
Solar
Cable B2
Cable B1
Building 319
150 kVA
Ship Shore
Busbar A Busbar B Busbar C
B2B
Aircon
CEE
Diesel
Cable A1
Cable A2
Dumpload
Solar
200 kVA
Grid busbar
Local busbar
Building 117
Mach set
Busbar 1
Busbar 2
Crossbar switch
Chg. post
D1 to 117-4
NEVIC
EDISON 3
630 kVA
Solar
Cable C1
Cable C2
Battery
Ext. 117-5
Ext. 117-2
CEE
EDISON 1
EDISON 2
100 kVA
Grid busbar
Lab busbar
NEVIC 1
NEVIC 2
NEVIC 3
NEVIC 4
NEVIC 5
NEVIC 6
NEVIC 7
NEVIC 8
NEVIC

Proposed analyses of operational robustness @ virtual aggregation

Timewise aggregation

- Monte-Carlo simulations including aggregation noise uncertainties of all power flow sources
  - source->carrier
  - carrier->carrier
  - source/carrier->service

Spatial aggregation

- Simulations with all infrastructure constraint parameters adjusted for aggregation noise