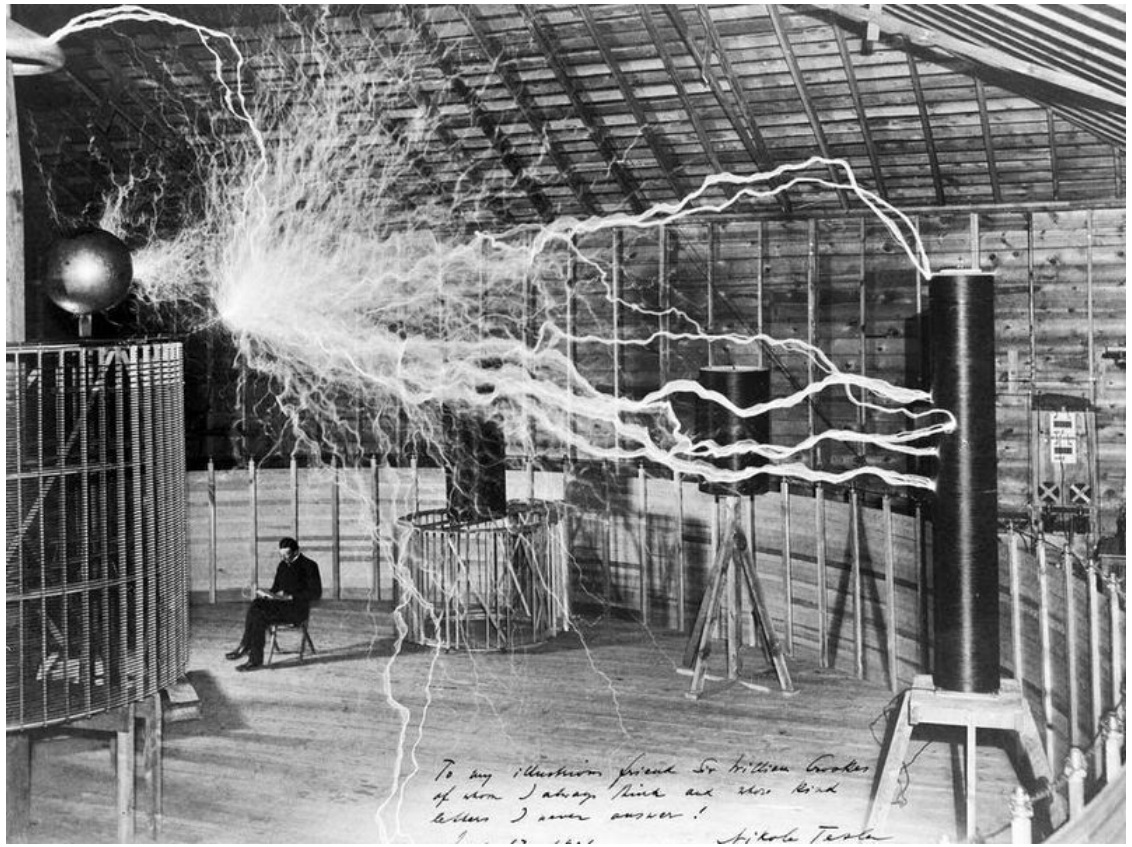
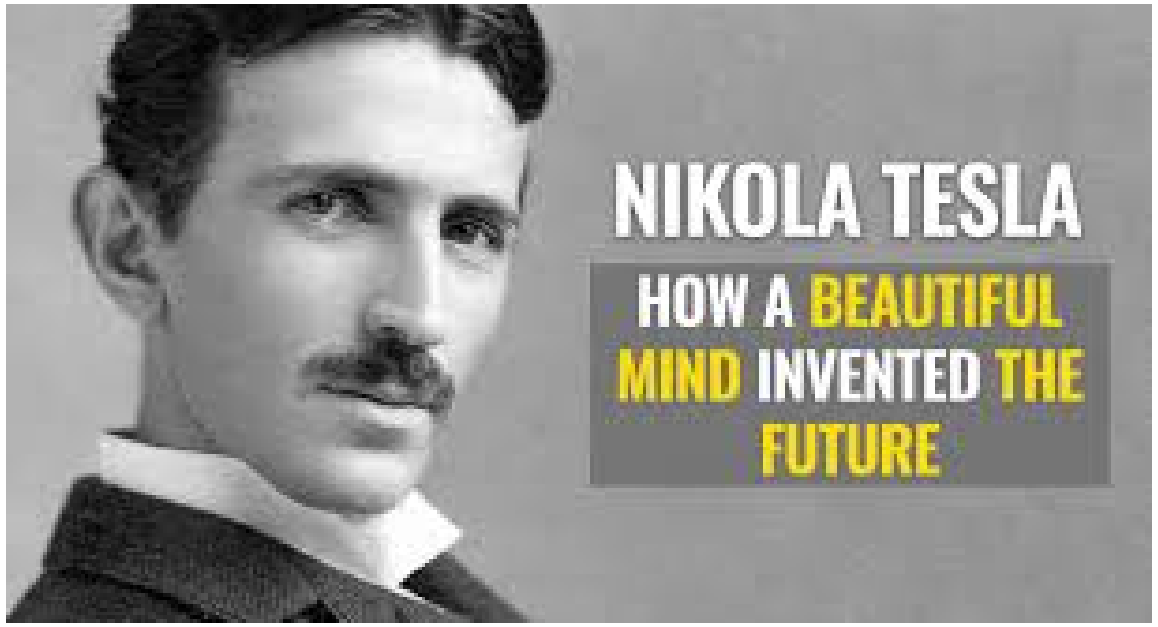
Batterier og smarte elnett

Bernt A. Bremdal

UiT & Smart Innovation Norway

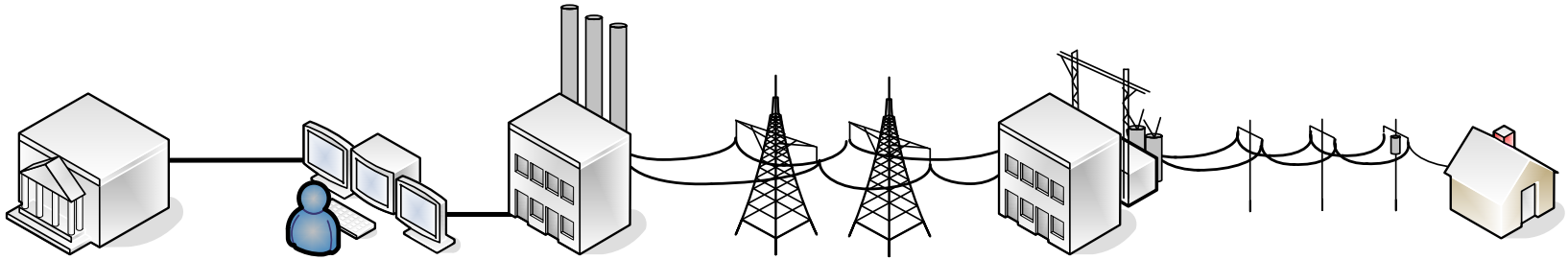
Norges Teknisk Vitenskapelige Akademi, Stavanger 17.april 2018





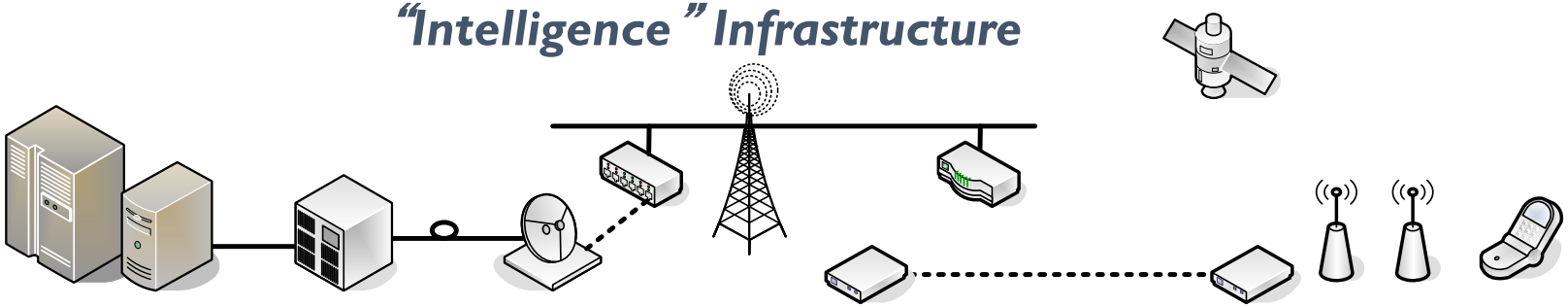
El-systemet: Historiens største og mest presise system

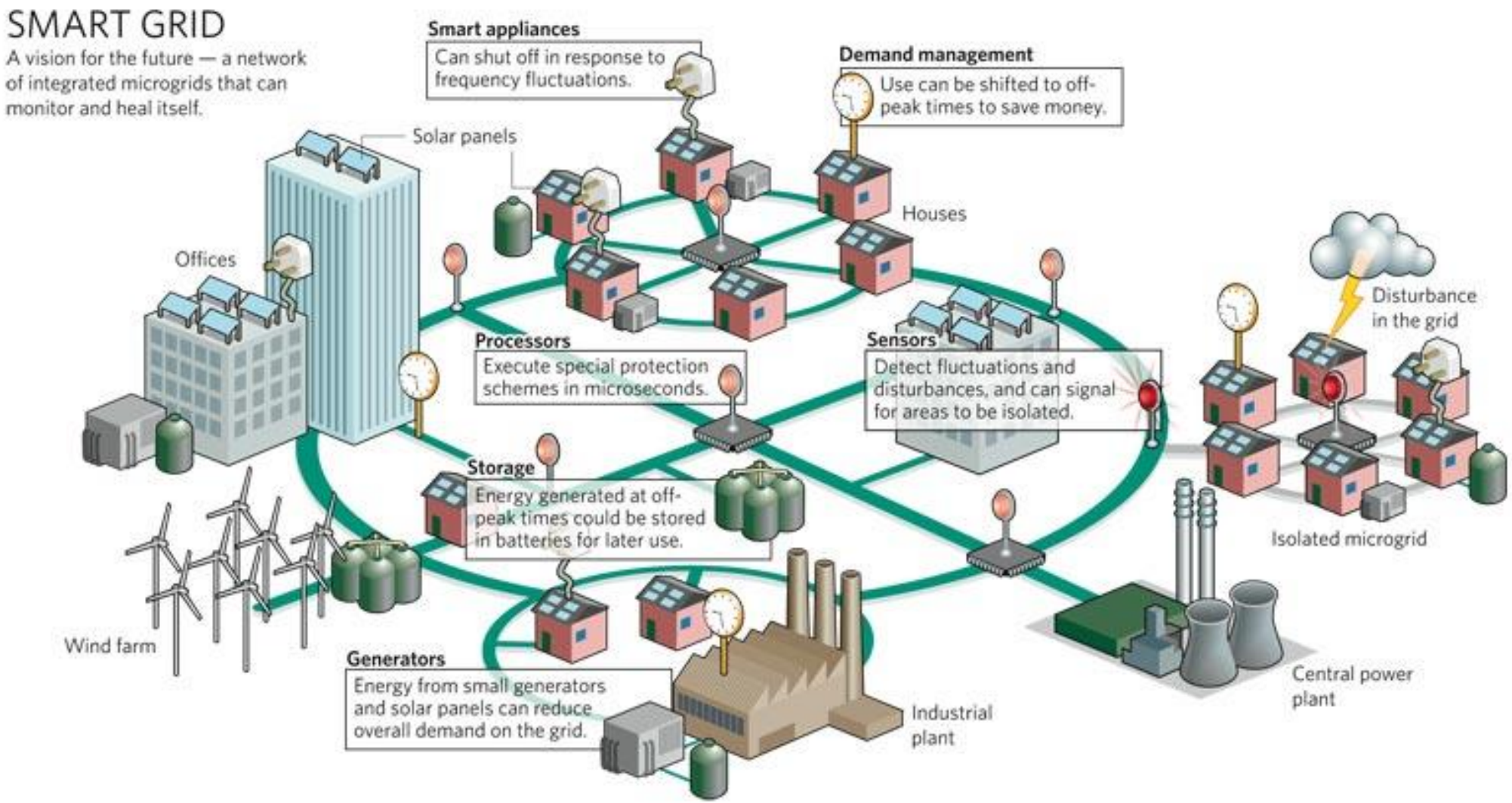
Mot et smartere el-nett



Electrical Infrastructure

"Intelligence" Infrastructure





Smart Grid = Smarte el-nett

Smart Society
Smart care
Big Data
Smart Working
Smart Energy
IOT
Smart Retail
End user driven Innovation
Smart product management
Smart building
Smart Home
Smart Mobility
Smart Cities: All you need to know

Klima og fornybar energi (smart energi)

Økt elektrifisering

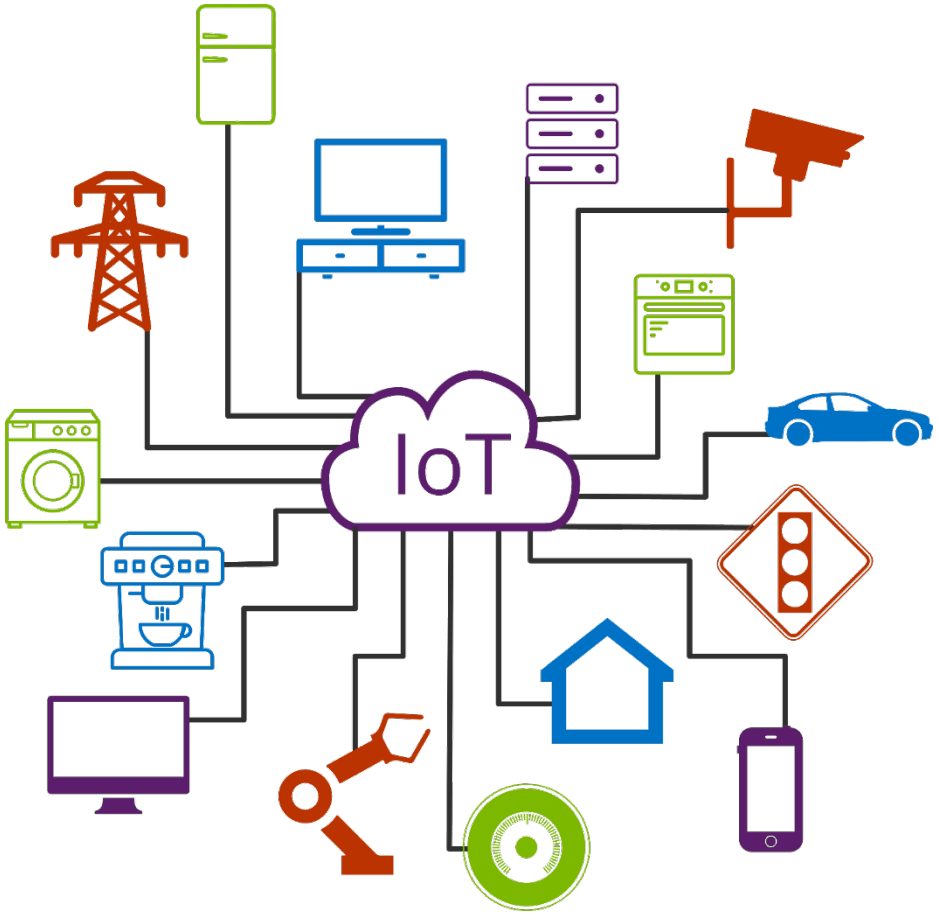
Digitalisering

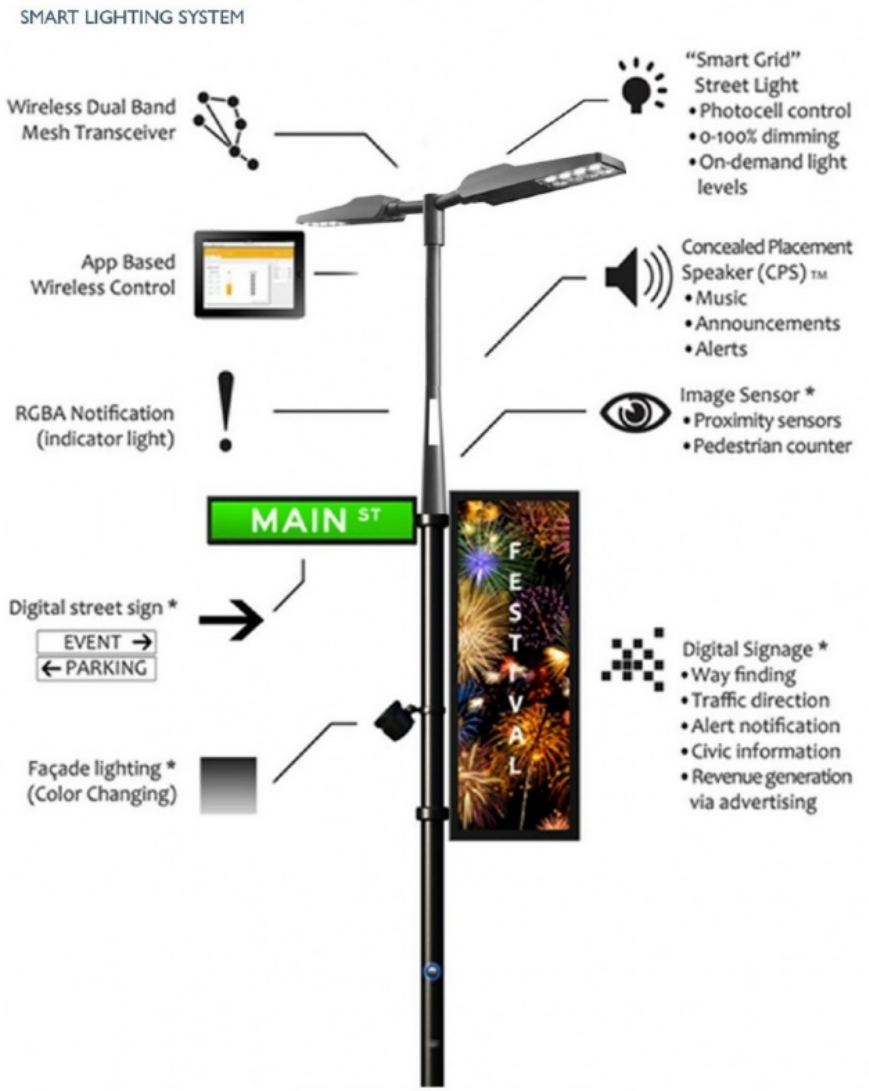
3 tunge drivere

Utnyttelse av lokal energiproduksjon basert på fornybare kilder

Økt elektrifisering

Tingenes Internet (Internet of Things = IoT)



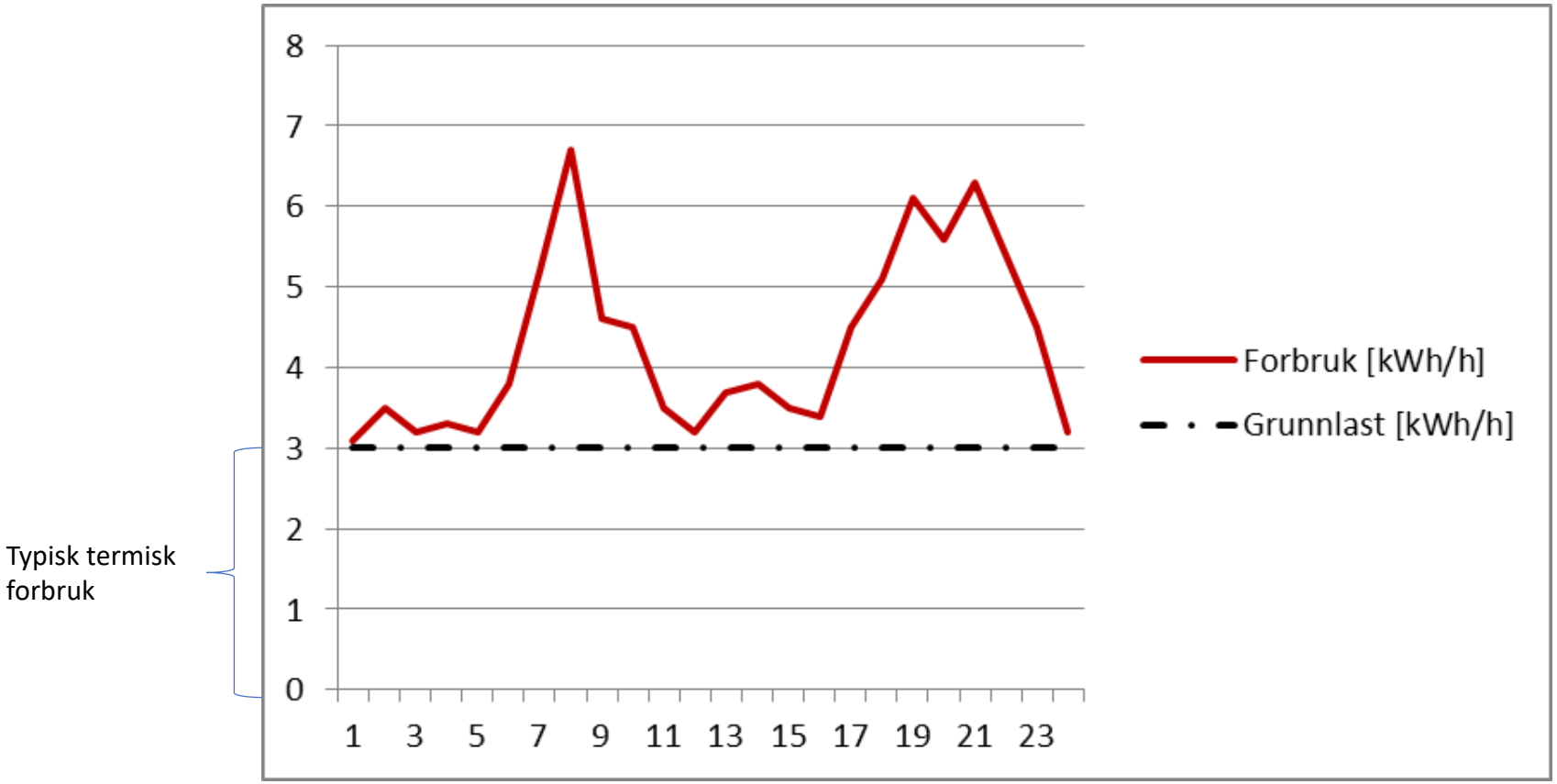


"The connected city"

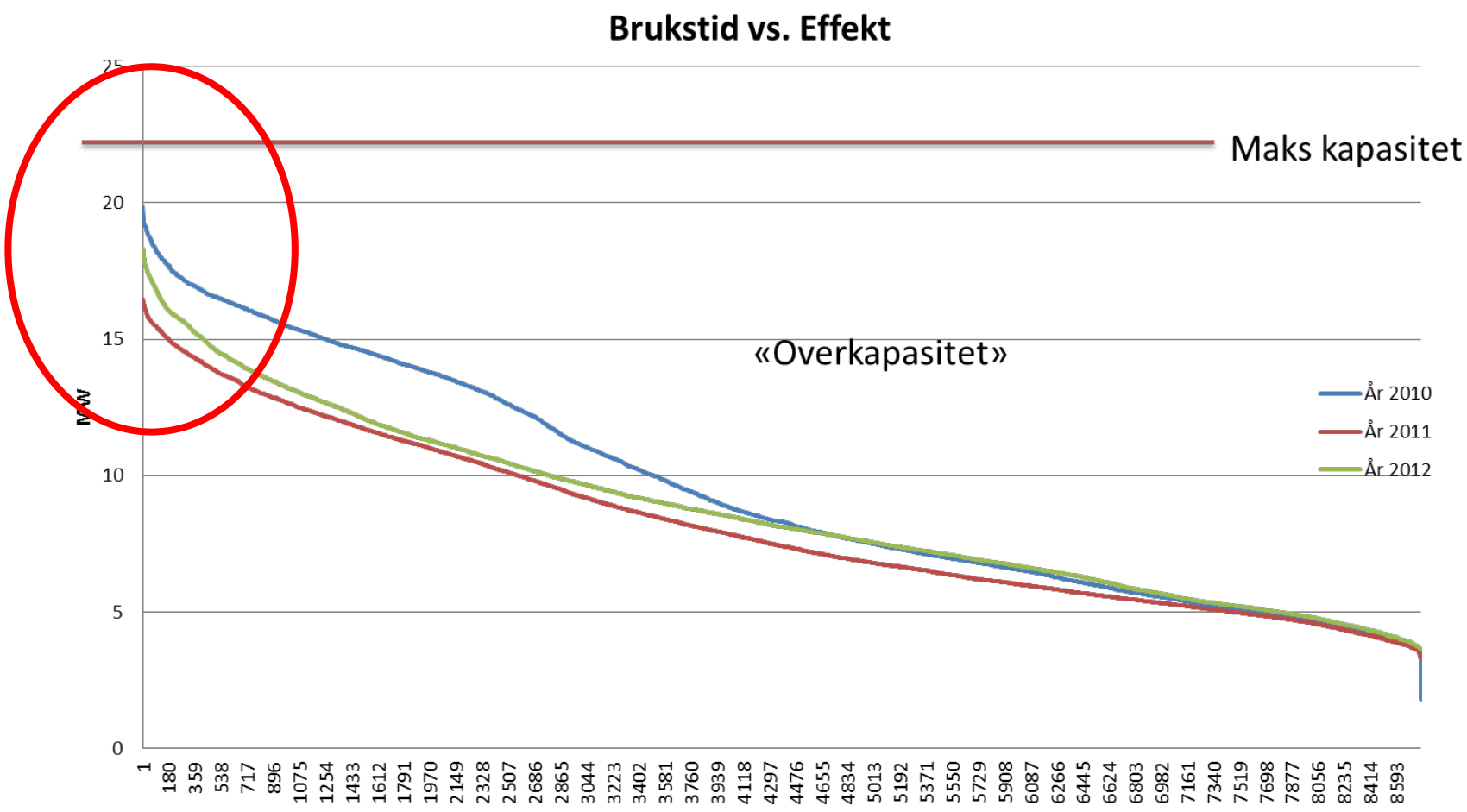
Noen utfordringer

Behovet for energifleksibilitet

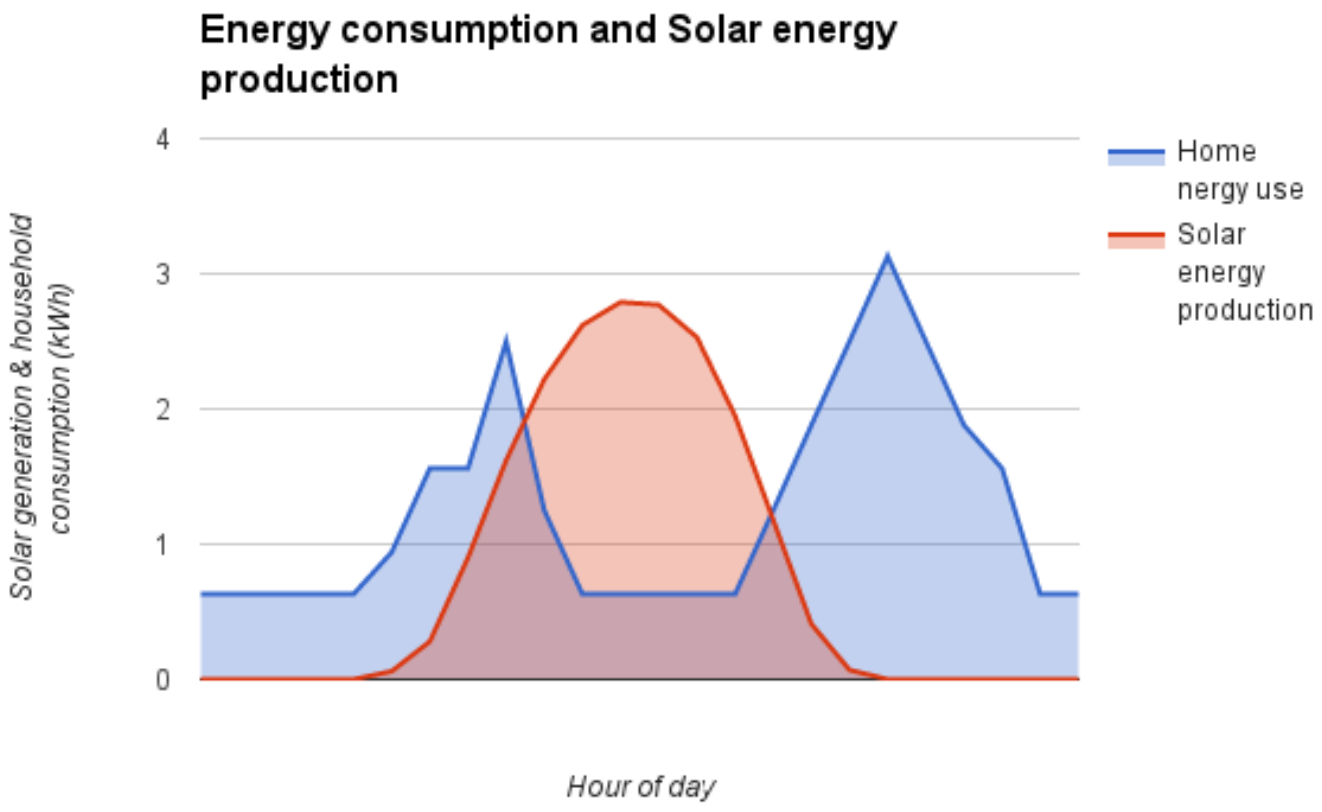
Typisk forbruksprofil for «Ola Nordmann»



Effekt kontra ENERGIFORBRUK



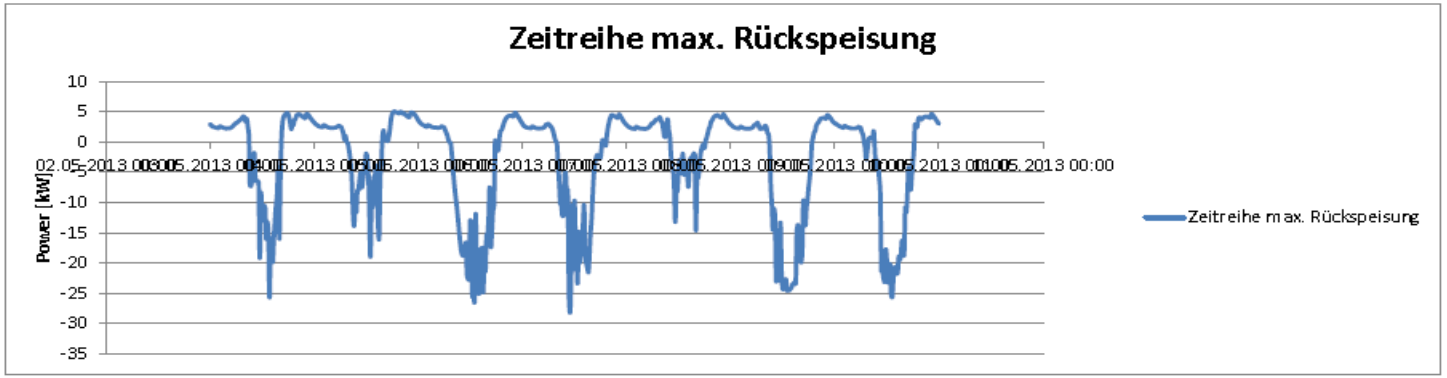
Ikke-styrbar solenergi “treffer” ikke forbruket til den vanlige husholdningen



Innmating

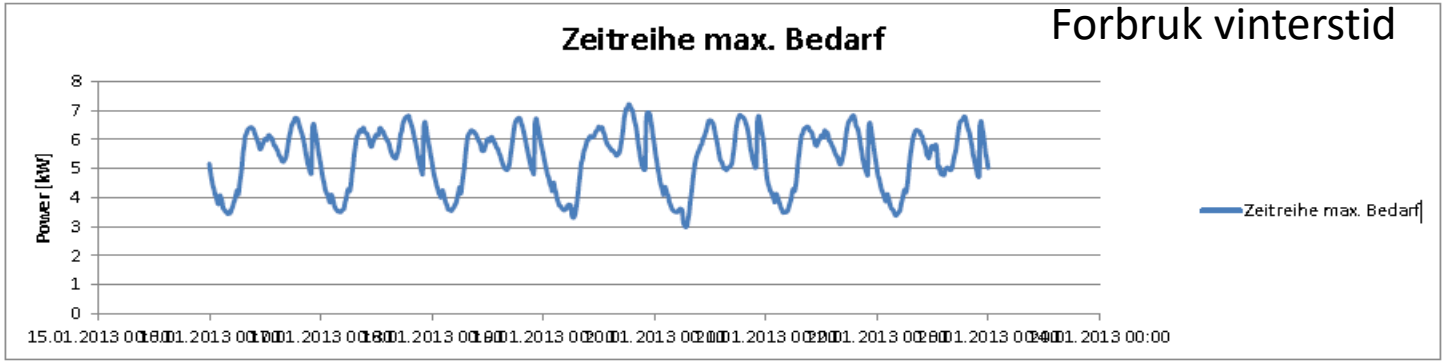
Innmating fra solcellepaneler

One week example of maximum feed of solar energy in a grid (3 May to 10 May 2013)



One week example of maximum consumption in a grid in wintertime without solar energy (16 to 23 January 2013)

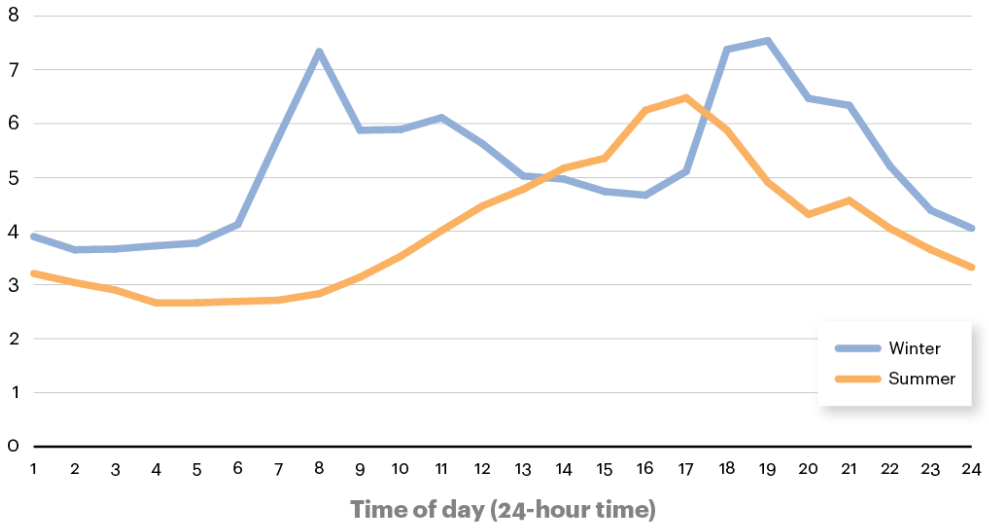
Forbruk vinterstid



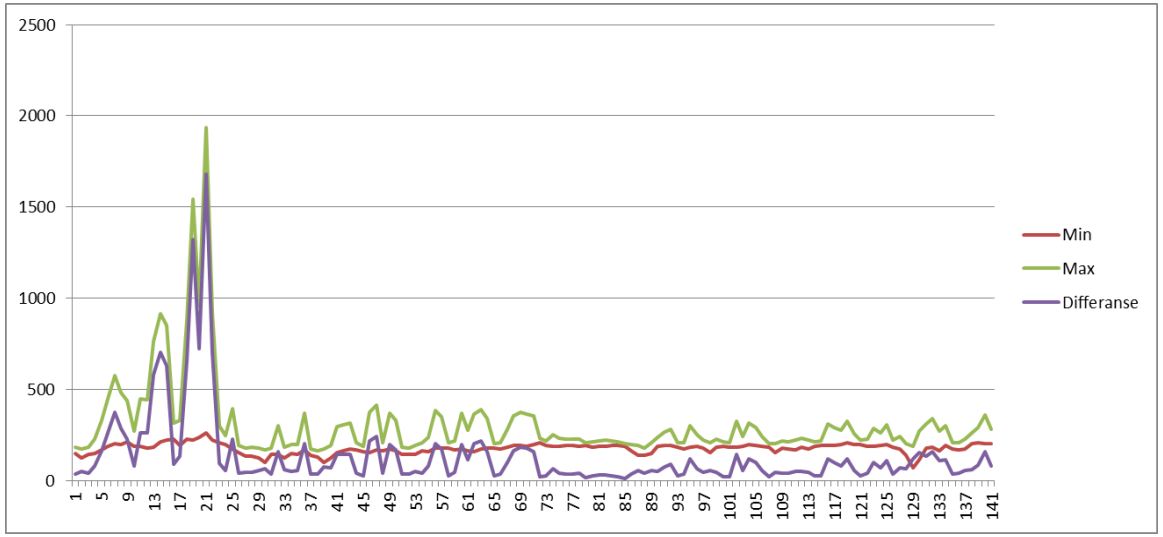
Kilde: SWRO – Rosenheim, Bayern

Prisvariasjoner i markedet

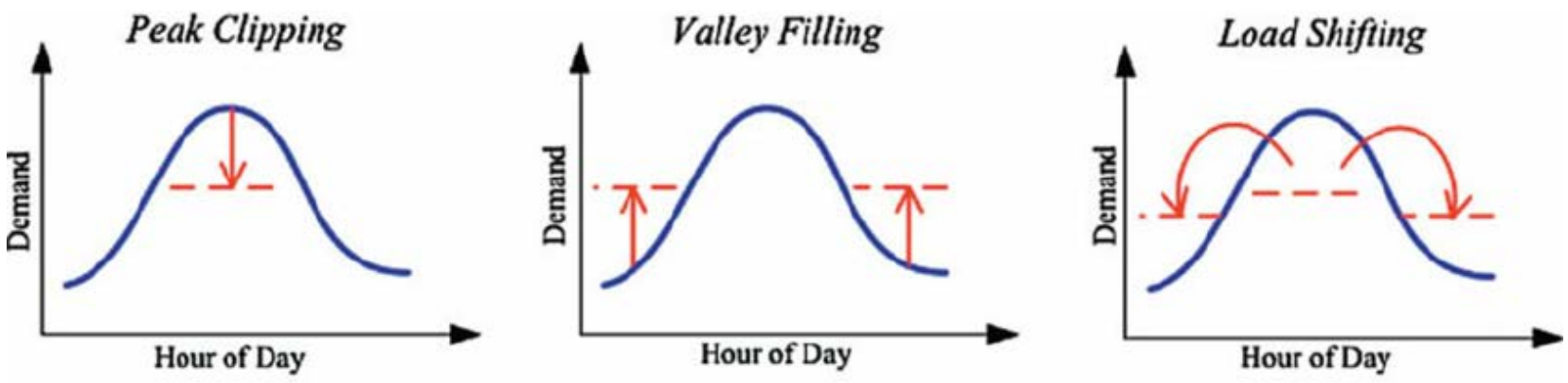
Hourly prices for power generation
(¢ per kilowatt hour)

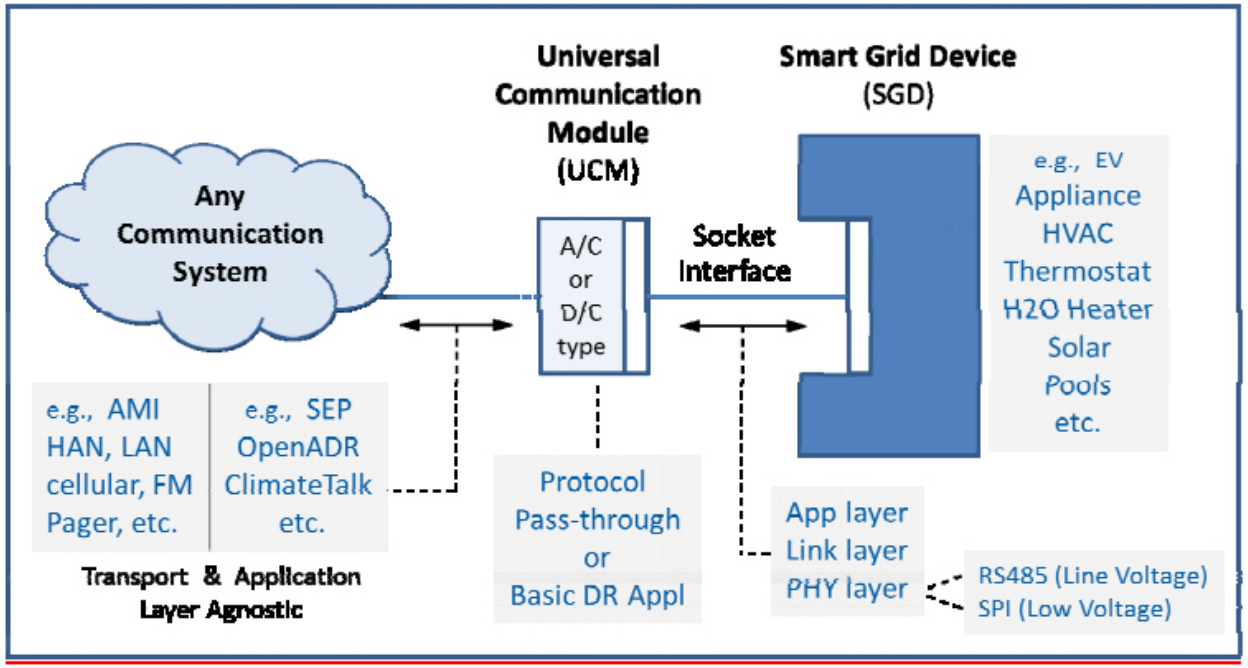


Sources: PJM; A.T. Kearney analysis

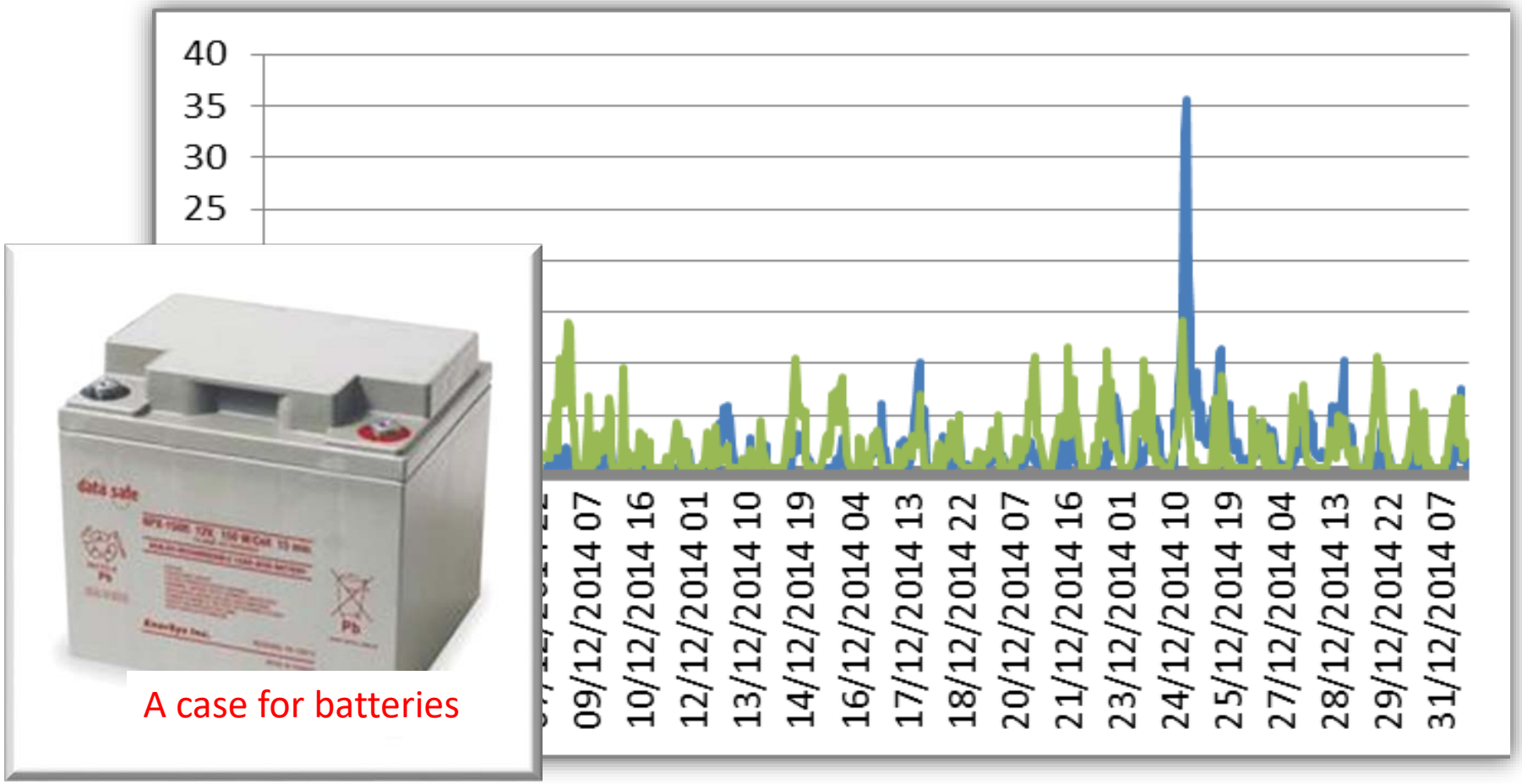


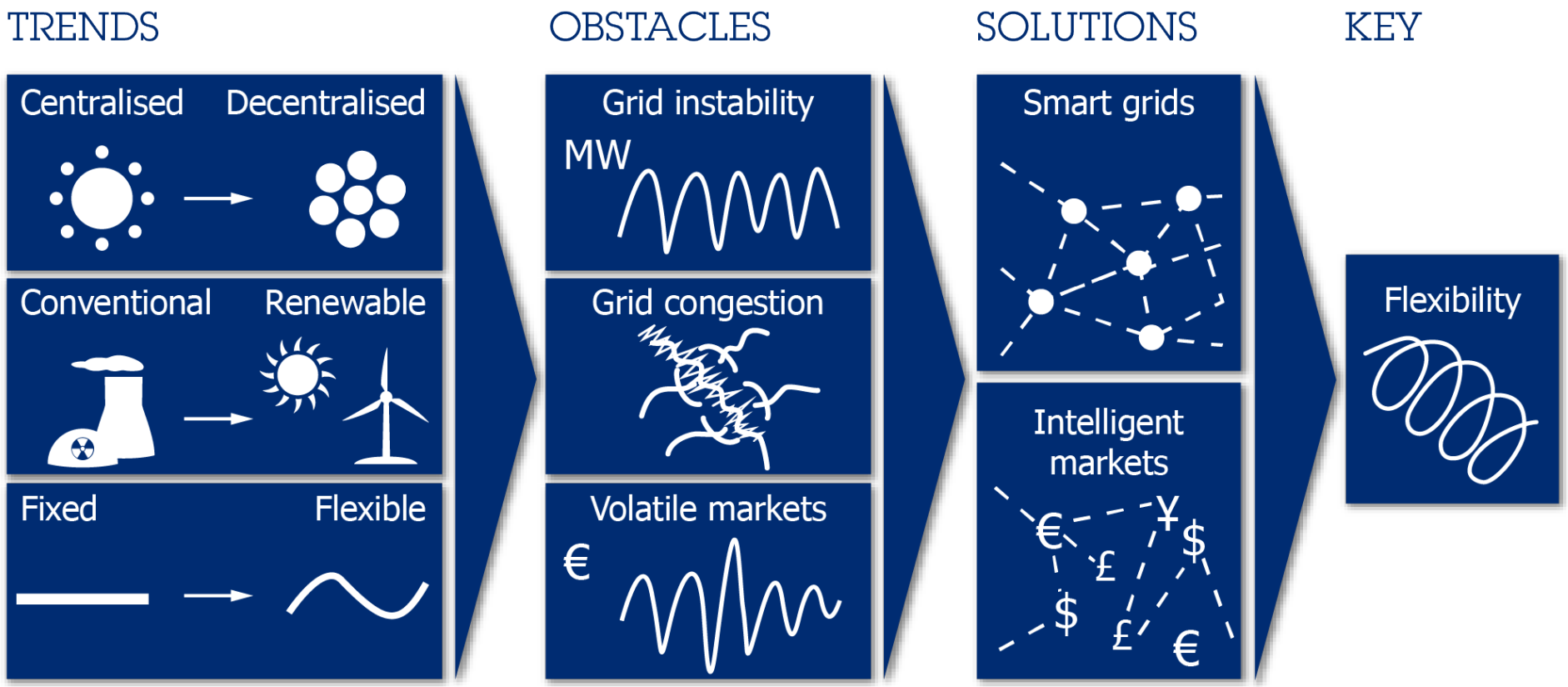
Behov for energifleksibilitet





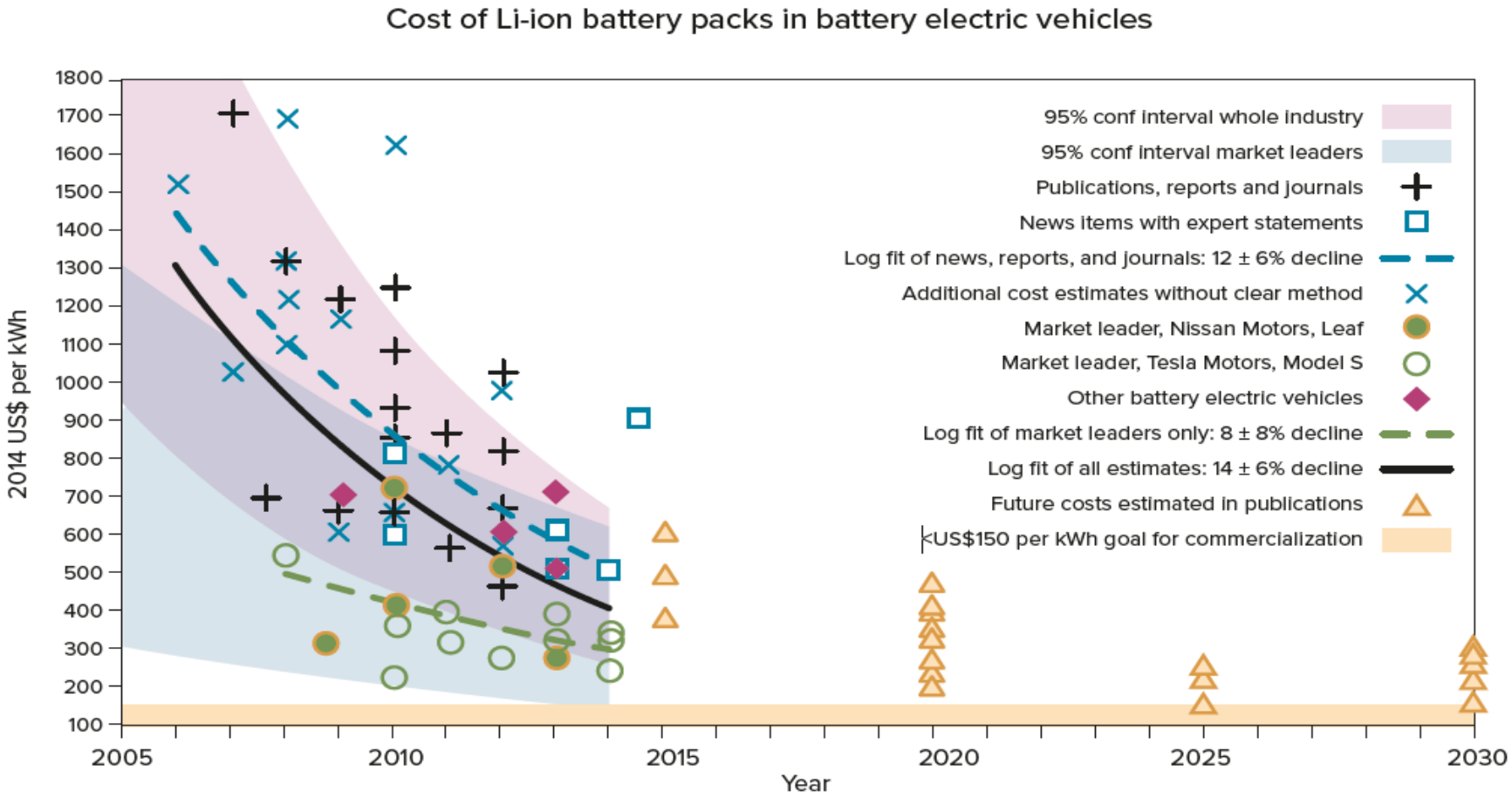
15-30 timer i året er svært lite fleksible




TRENDS
Centralised
Decentralised
Conventional
Renewable
Fixed
Flexible
OBSTACLES
Grid instability
MW
Grid congestion
Volatile markets
€
SOLUTIONS
Smart grids
Intelligent markets
€
¥
$
£
$
£
€
KEY
Flexibility

Lagringsteknologi: Batterier

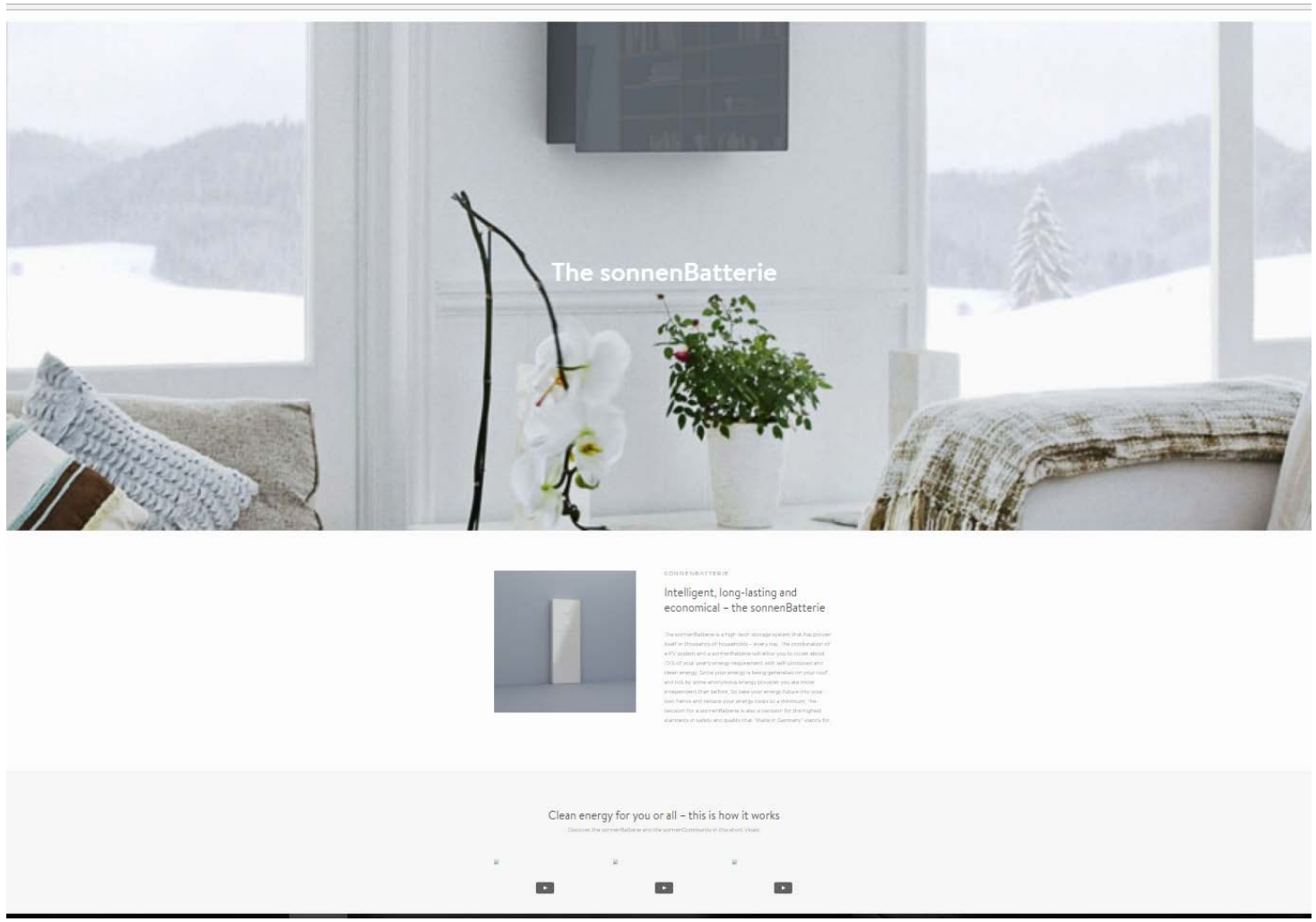
Prisene faller



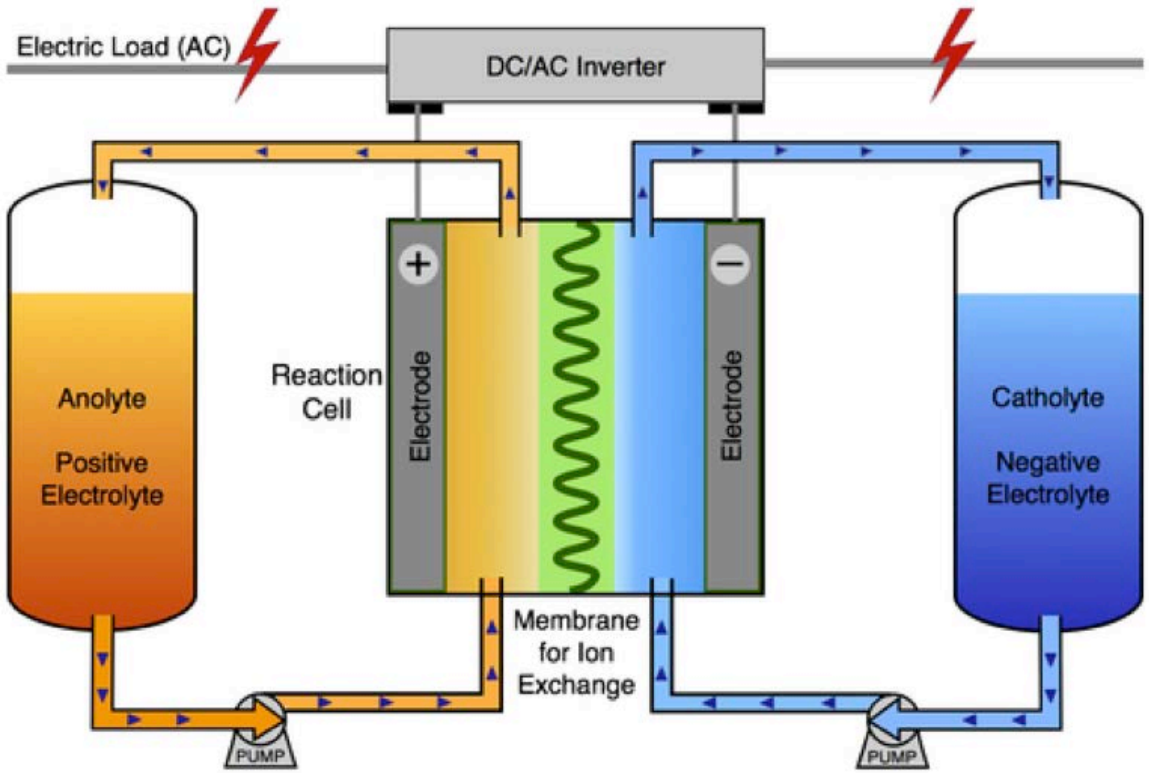
*Rapidly Falling Costs of Battery Packs for Electric Vehicles, *Nature Climate Change*, 2015

Ulik industri ser store muligheter

Sonnen

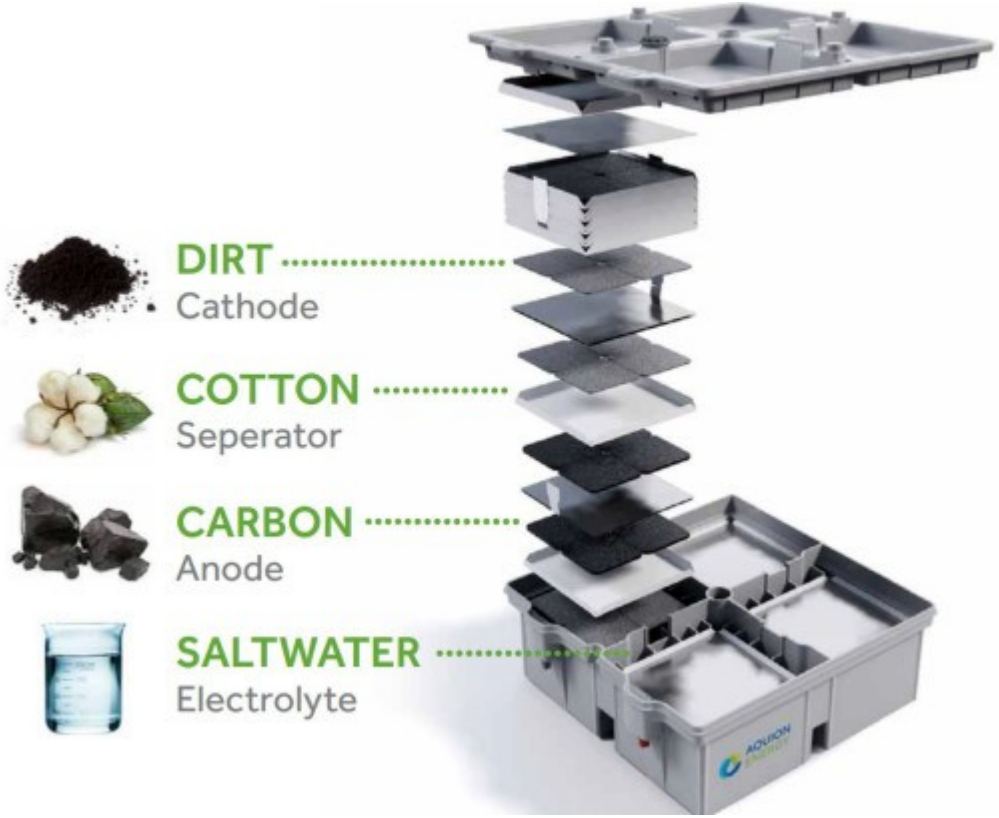

The sonnenBatterie
Intelligent, long-lasting and economical – the sonnenBatterie
Clean energy for you or all – this is how it works

Ulike teknologier utvikles og forbedres hele tiden

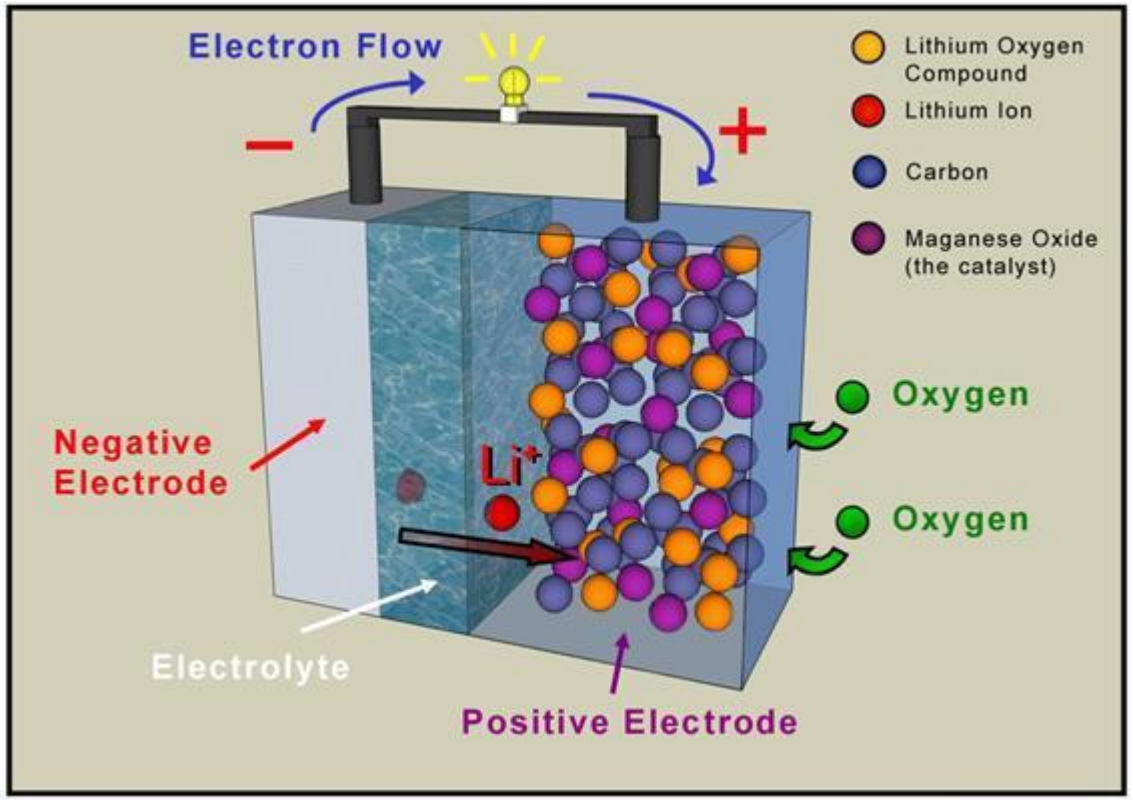


REDOX/FLOW batterier

Saltvannsbatterier – “et batteri du kan spise”

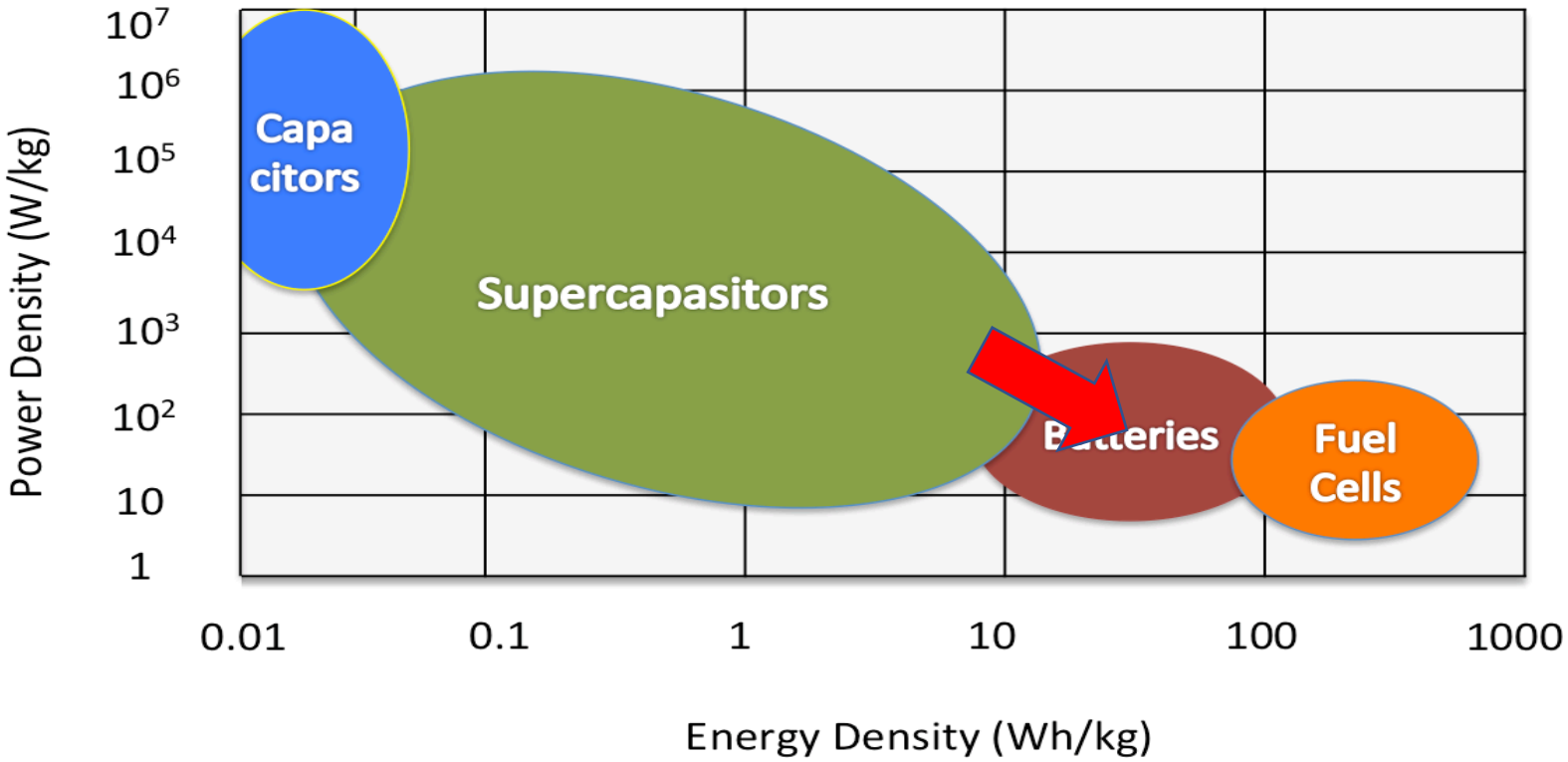


Lithium-luft batterier – “nesten like høy energitetthet som bensin”



Toyota
General Motors

Superkondensatorer



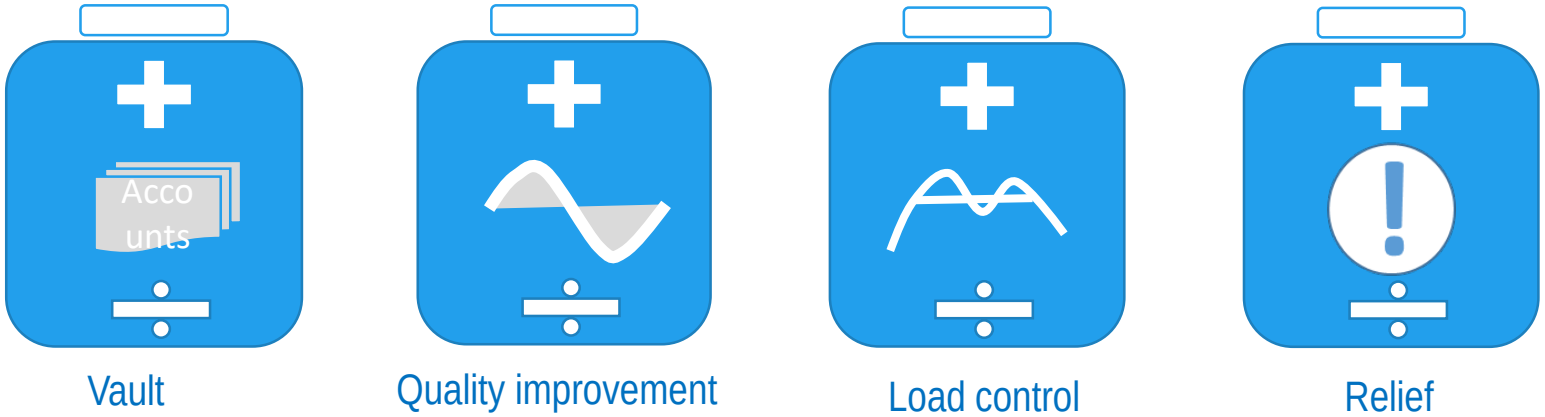
Batterier på hjul

Unit	Capacity	Sales price	NOK/kWh
Tesla 75 D	75 kWh	622 700	8 302
Tesla 100 D	100 kWh	795 650	7 956
Tesla P100D	100 kWh	1 105 150	11 015
Nissan Leaf	40 kWh	290 850	7 271
VW eGolf	35,8kWh	310 900	8 684
Tesla Power Wall	14 kWh	57 000	4 071
Opel Ampera-E	60 kWh	359 900	5 998

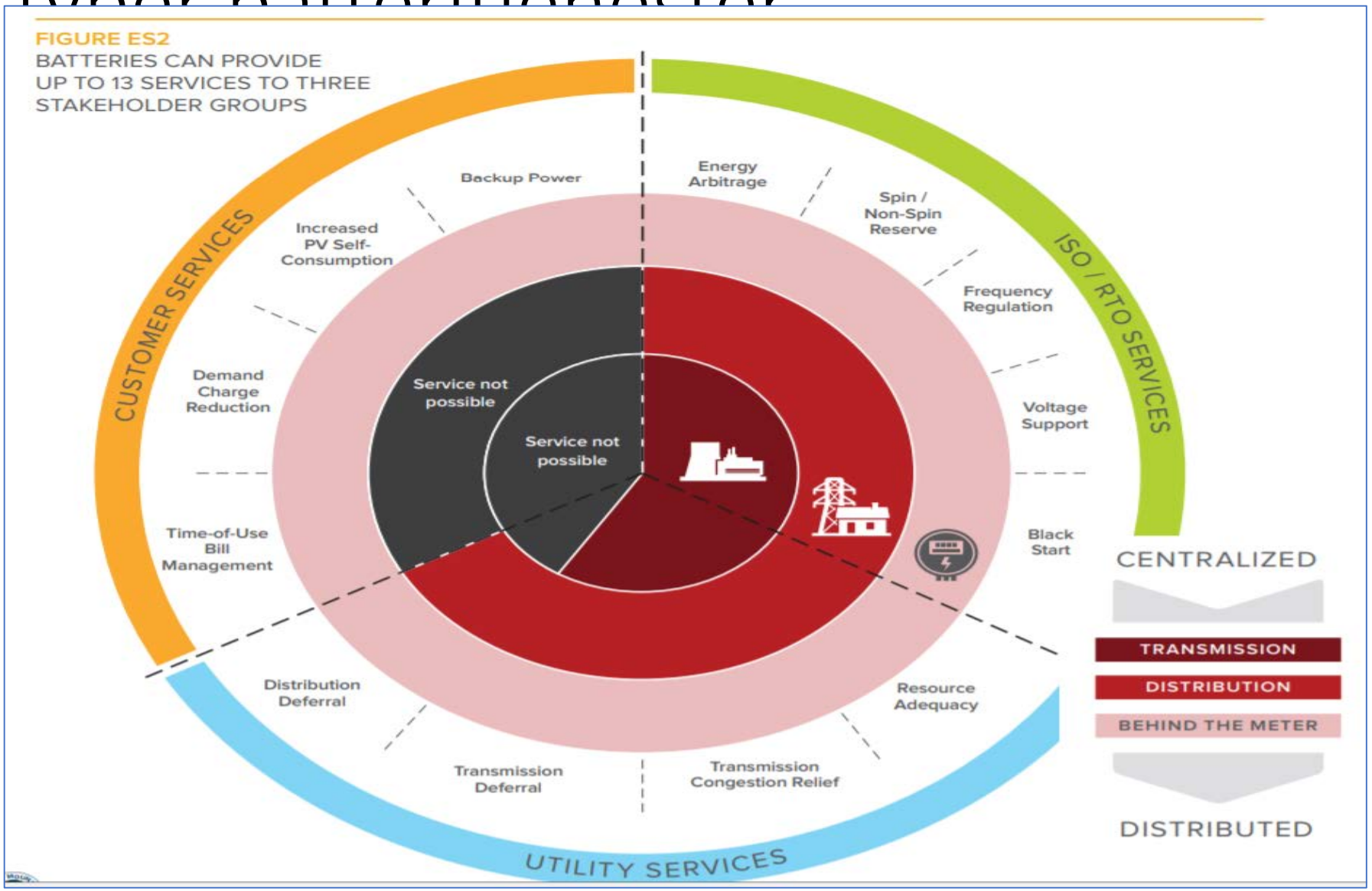
Et case for bildeling og bil-til-nett/bygg forsyning (V2G/V2B)
OCPP 2.0 er her!

Langtidsparkering på en flyplass - et kraftverk?

Hva kan batterier bidra med?



13 typer batteriteknoster



Source: RMI

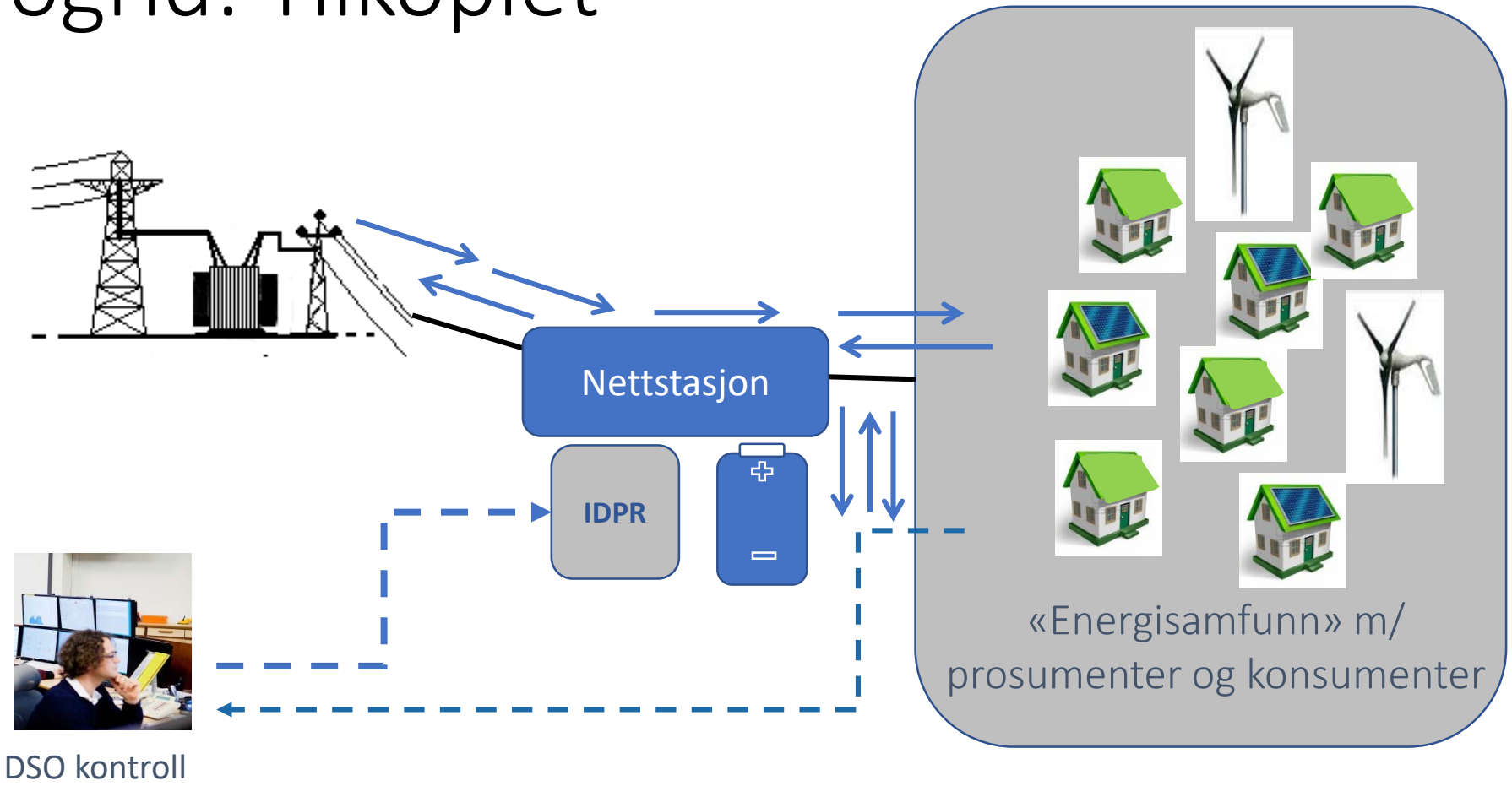
Verdi for hvem? (1)

- Hus/byggeier/anlegg
  - Økt selvkonsum
  - Salg av fleksibilitet til markedsaktør og nettselskap
  - Reservestrøm
  - TOU og arbitrage muligheter
- Produsenter: Ikke-styrbar produksjon
  - Buffer – taktisk innmating
  - Arbitragemuligheter
- DSO/TSO
  - Bootstrapping støtte
  - Reservekraft
  - Freksvensregulering
  - Spenningsregulering
  - Fasebalansering
  - Kapasitetsavlastning (alternativ til utbygging/oppgradering av nett)
  - Overføringsstøtte

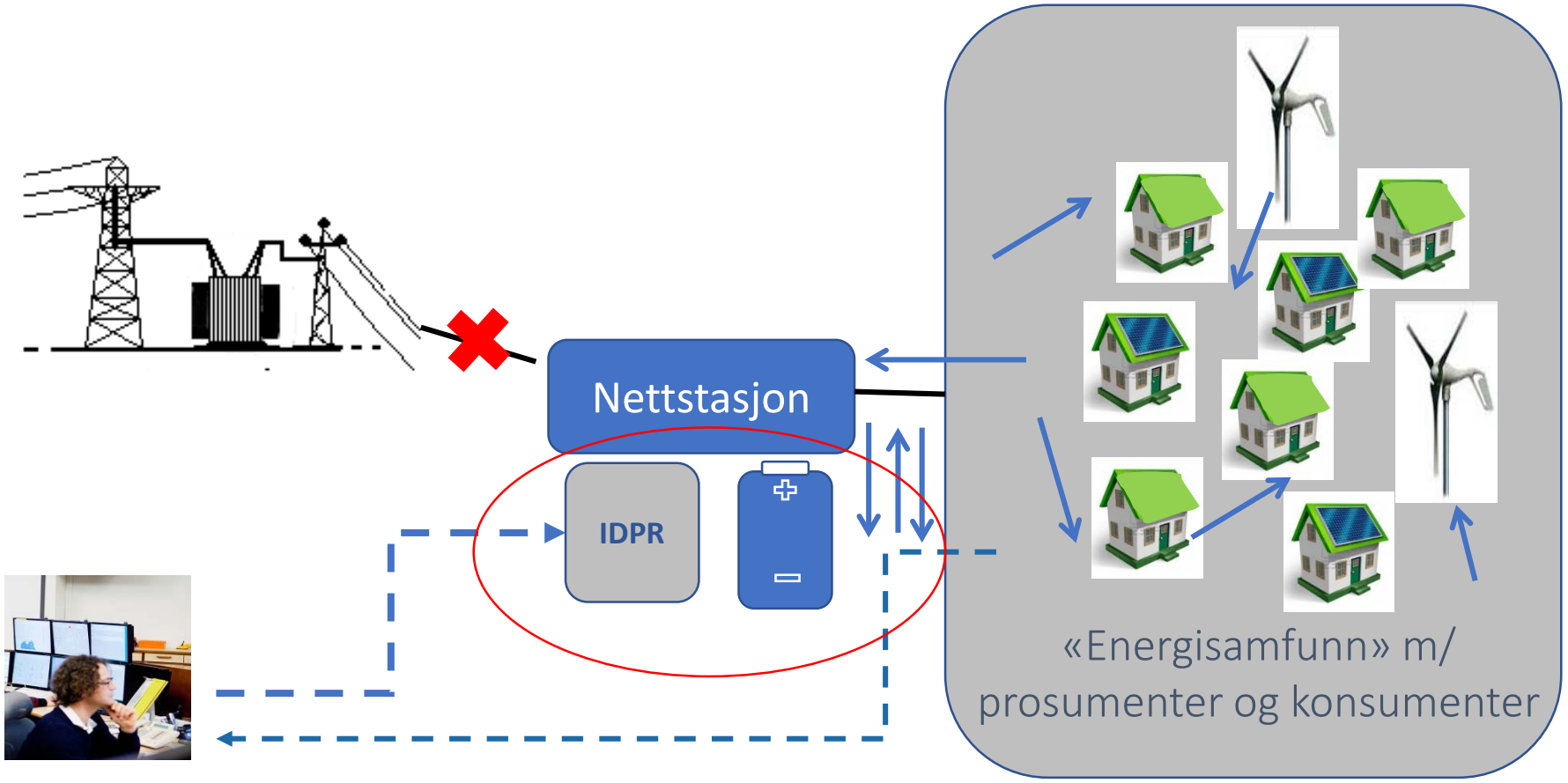
Verdi for hvem? (2)

- **Trafikk og anlegg**
  - Rekkevidde
  - Komfort
  - Bekvemmelighet (eks. REDOX)
  - Salg av fleksibilitet (V2G)
- **Forhandleren**
  - Konsolidering av fleksibilitet for sentrale markedsoperasjoner
  - Aggregering og salg av overskuddstrøm til DA og balansemarkedet
  - Kvalitetsgarantier (grønne sertifikater ++)
- **Tjeneste/produktleverandøren**
  - Salg av nye gadgets (display/invertere/EMS/HAS)
  - Konsolidering av fleksibilitet for nettrelaterte operasjoner
  - Organisering av lokal handel/marked
  - Salg og formidling av høy-margin tilleggstjenester og produkter (eks. Apper)
  - Energieffektivisering
  - Effektreduksjon
  - Støtte til økt selvkonsum
  - Støtte til økt
  - Teknisk diagnose
  - Sikring og Forsikring
  - Vaktmestertjenester
  - Etc.

Microgrid: Tilkoplet



Mikronett: Frakoplet



DSO kontroll

Microgrid Sandbakken

Et Business Case for boligsameier i Norge baserte på lokale energimarkeder og batterier

Maksimal selv-konsum. Høy avlastning for nett

$$min \sum_{i \epsilon I} \sum_{j \epsilon I} c_{ij,t}\, q_{ij,t}$$

$$p_{i,t} - d_{i,t} - \sum_{j \in I} \left(q_{ij,t} - q_{ji,t}\right) = 0 \qquad \forall i \in I \; except \; \{g\}$$

$$\sum_{i \in I} (p_{i,t} - d_{i,t}) \leq \sum_{i \in I} q_{ig,t}$$

$$-(\sum_{i \in I} (p_{i,t} - d_{i,t}) \leq \sum_{i \in I} q_{gi,t}$$

$$q_{ij,t} \leq \bar{\bar{z}} \quad \forall i,j \; \in I$$

$$q_{ij,t} \geq 0 \quad \forall i,j \; \in I$$

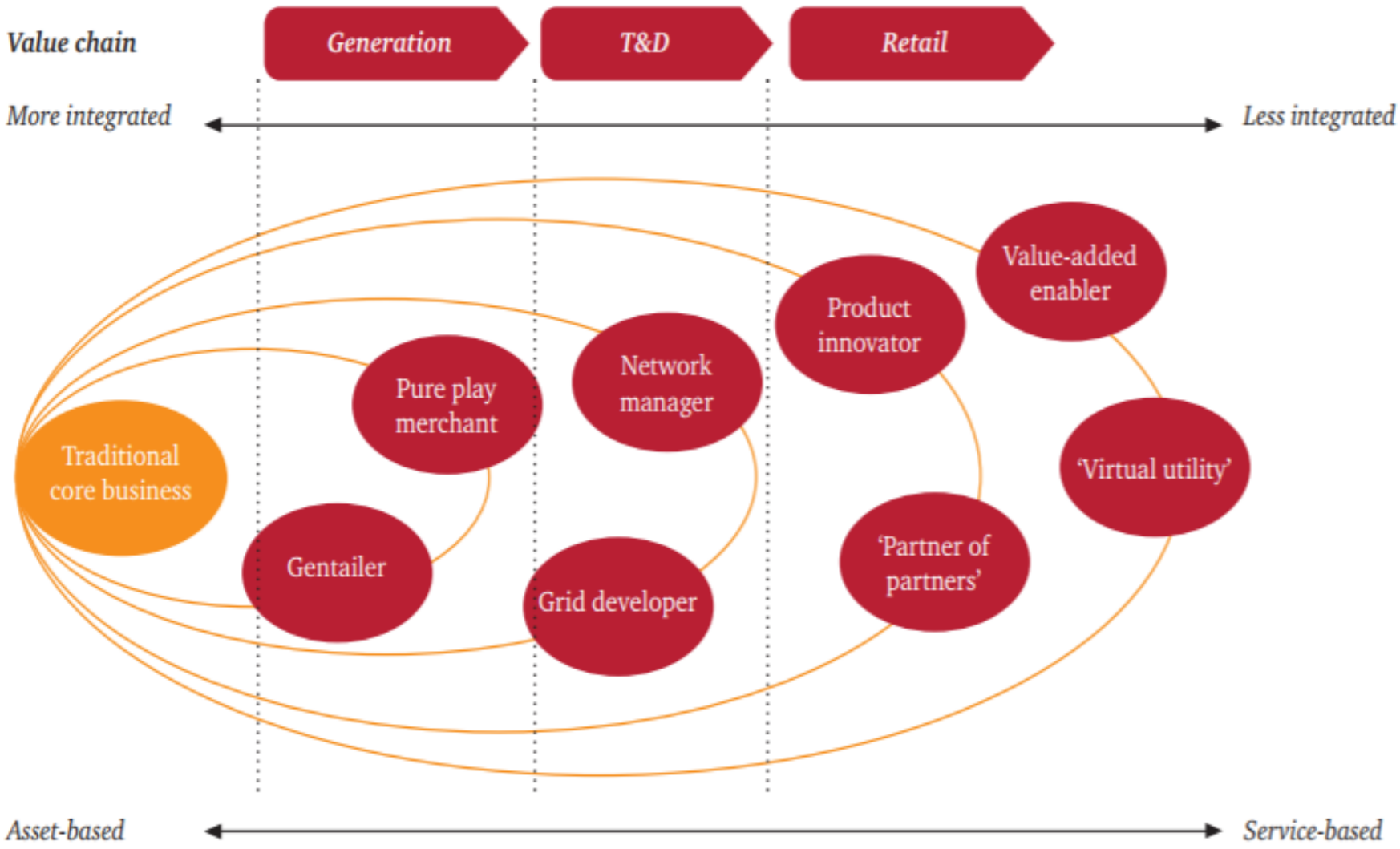
Distributed control through peer2peer trade.

Constraints (Norway) $\tilde{c}_{t1} < \left(c_{spot,t} + c_{fixed/t} + c_{energy,t} + c_{effekt,t}\right)$*1,25

$\tilde{c}_{t2} >$ *spot price*

(Basert på Mengelkamp et al 2017)

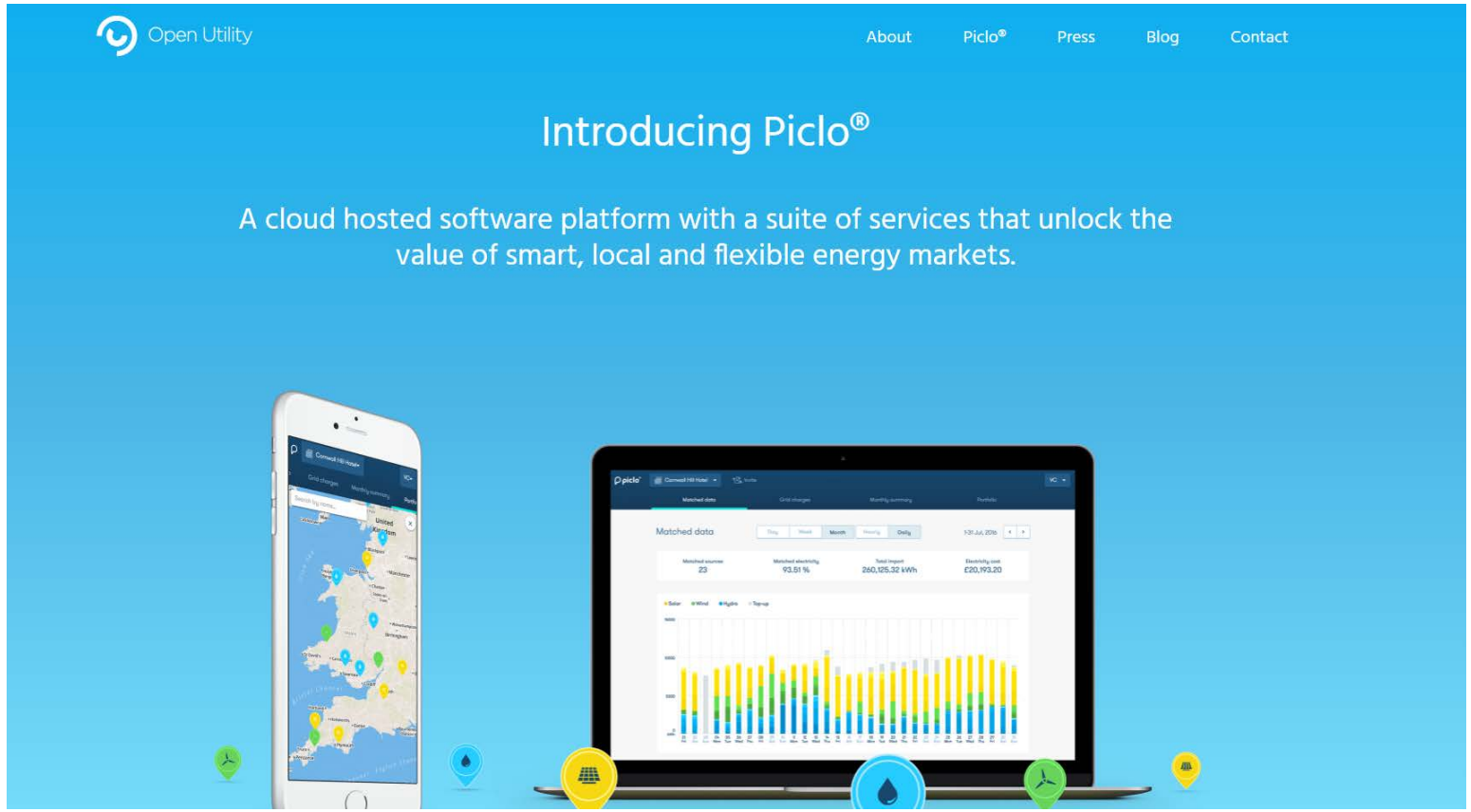
Tjenester: Lag på lag

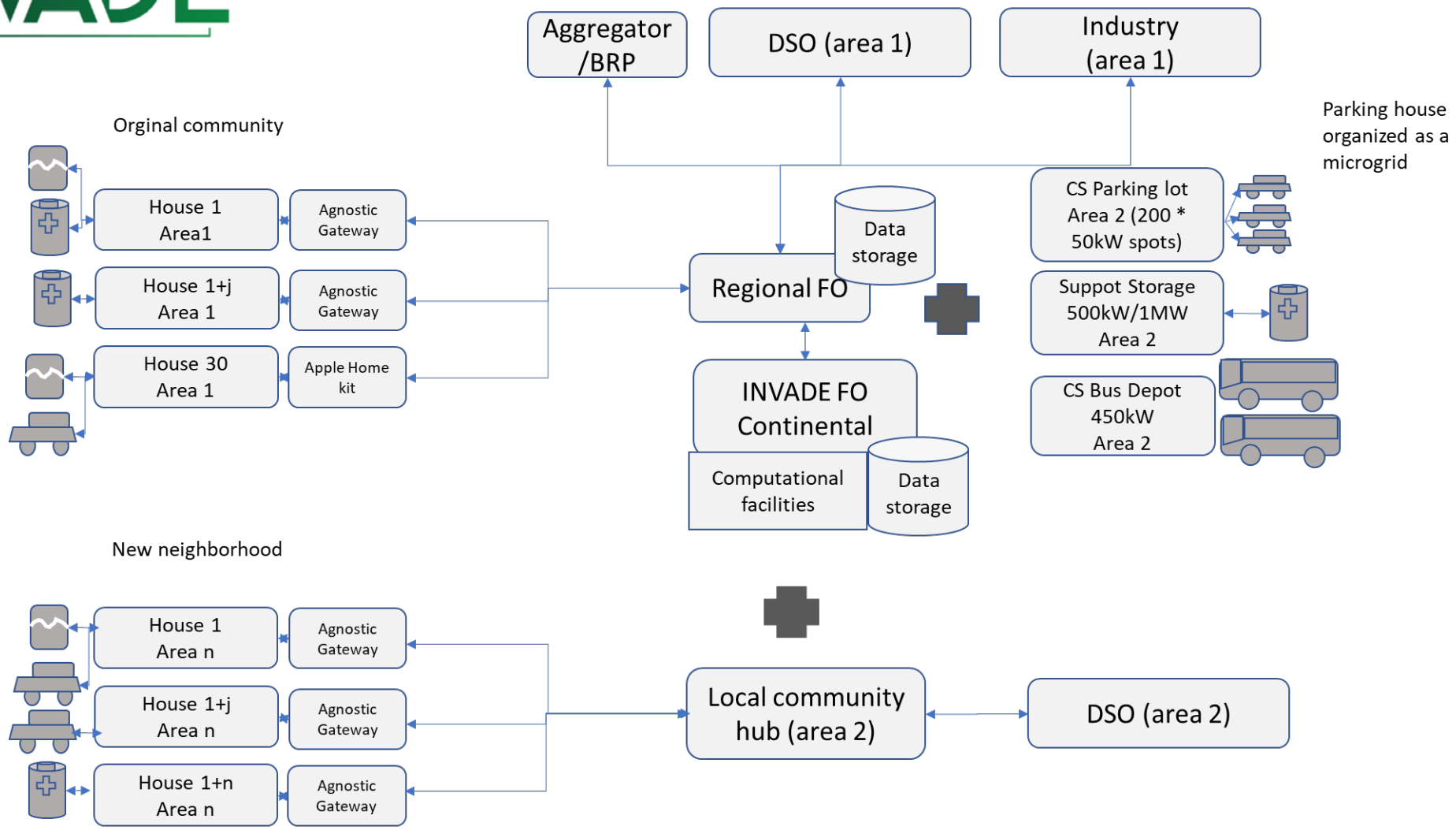


Platfformbaserte virksomheter med store vekstambisjoner

See also D3.2 and D9.1

Open Utility i UK




Aggregator /BRP
DSO (area 1)
Industry (area 1)
Parking house organized as a microgrid
Orginal community
House 1 Area1
Agnostic Gateway
House 1+j Area 1
Agnostic Gateway
House 30 Area 1
Apple Home kit
Data storage
Regional FO
CS Parking lot Area 2 (200 * 50kW spots)
Suppot Storage 500kW/1MW Area 2
CS Bus Depot 450kW Area 2
INVADE FO Continental
Computational facilities
Data storage
New neighborhood
House 1 Area n
Agnostic Gateway
House 1+j Area n
Agnostic Gateway
House 1+n Area n
Agnostic Gateway
Local community hub (area 2)
DSO (area 2)

SMART INNOVATION NORWAY

TAKK FOR MEG!

Takk til kolleger og sponsorer i de ulike prosjektene som har bidratt med ny innsikt og utviklet nye modeller for smarte el-nett og smarte energimarkeder

The INVADE has received funding from the *European Union's Horizon 2020 Research and Innovation programme* under Grant Agreement No 731148.

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