TotalFlex

- et market based system for flexibility based on the Flex-Offer concept

Presentation at Cities workshop januar 25th 2017

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TotalFlex is funded by the ForskEL programme under ENERGINET.DK

TotalFlex presentation

- Agenda
  - Introduction to Neogrid Technologies
  - Introduktion to TotalFlex
  - Flex-Offer concept
  - Market Place for flexibility actors
  - Market Place functionality
  - Pricing
  - Settlement
  - Next step

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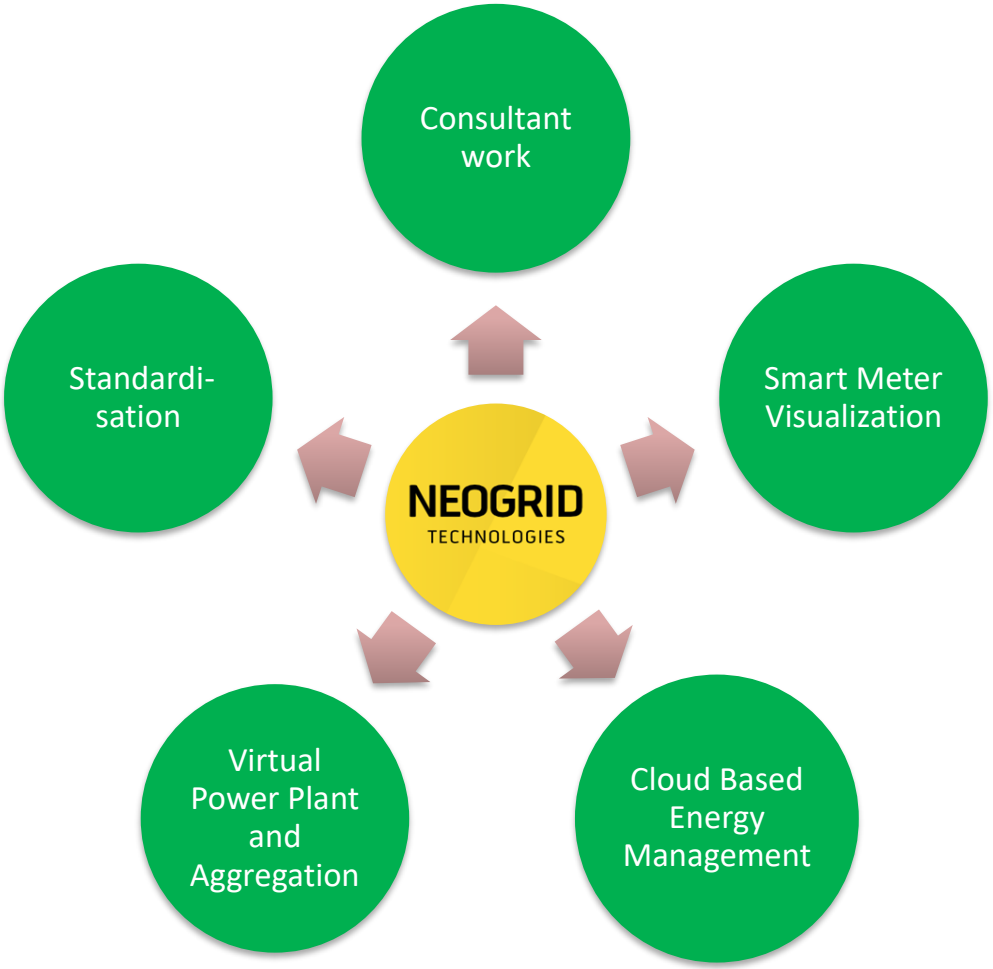
Neogrid Technologies ApS

Background

- Founded in 2009
- +30 years experience from mobile communication
- Involved in 10+ national and international research projects within Smart Grid And Energy Optimization
- 7 employees
- www.neogrid.dk



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Project highlights

- Time Schedule: Start 2012 – End 2016
- Partners:

AALBORG UNIVERSITET

Center for Indlejrede Software Systemer

Department of ENERGY TECHNOLOGY E.T.

daisy HCI

Copenhagen Business School HANDELSHØJSKOLEN

NYFORS

zensehome

NEAS ENERGY

conscius

- Project Management: NEOGRID TECHNOLOGIES
- Budget: 4.7 M€/41 MY

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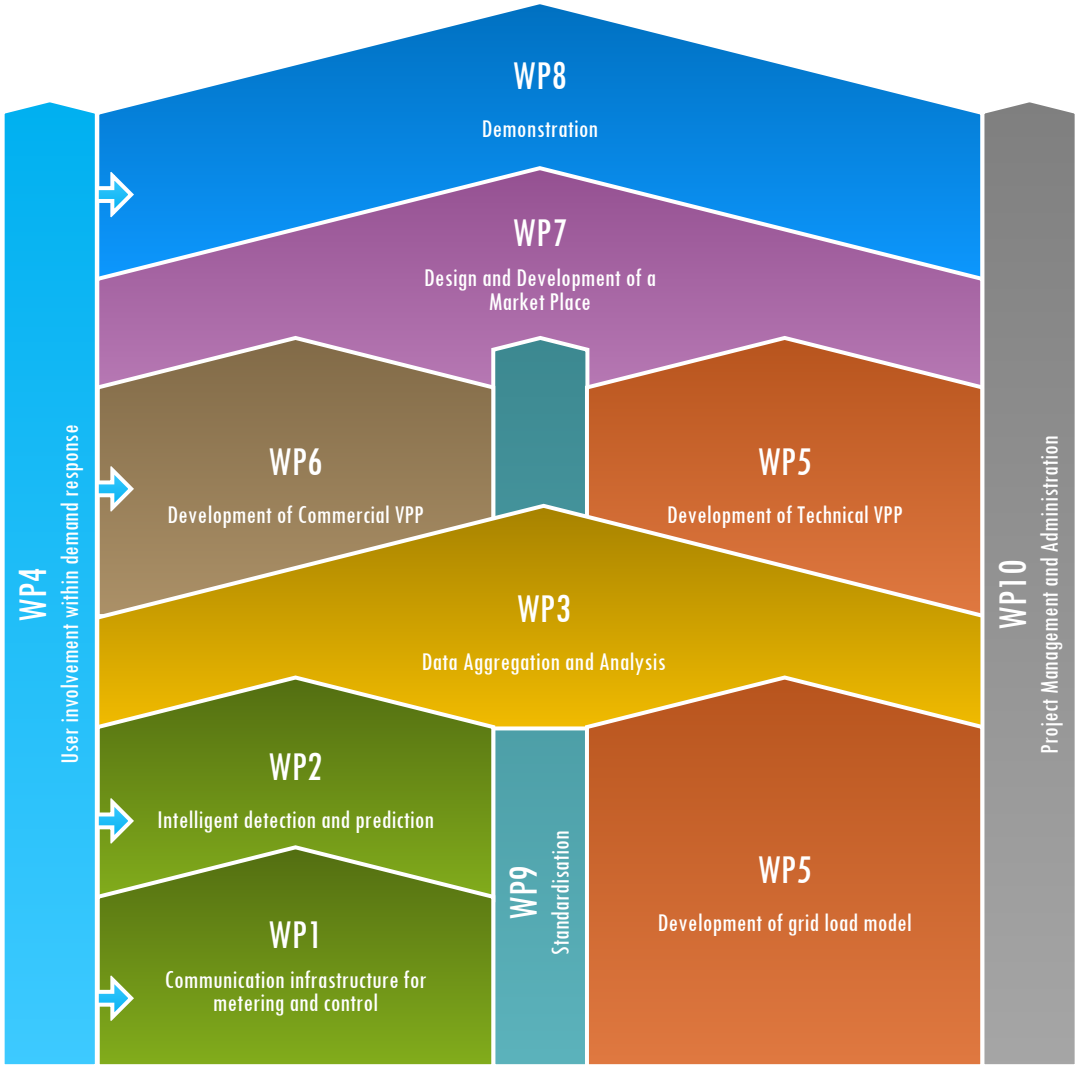
Work Packages



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The global challenge

TotalFlex focuses on these two major global challenges:

Increasing share of fluctuating electricity in the grid	
• Activation of demand response • Syncronise consumption with production	• Export of “cheap” electricity out of Denmark • Major expense to “stand by” power plants
Global power consumption increasing due to increased wealth and conversion from fossile-based consumption to green consumption (i.e. heat pumps and Electical Vehicles)	
• Activation of demand response • Move consumption away from peak hours	• Strengthen the grid

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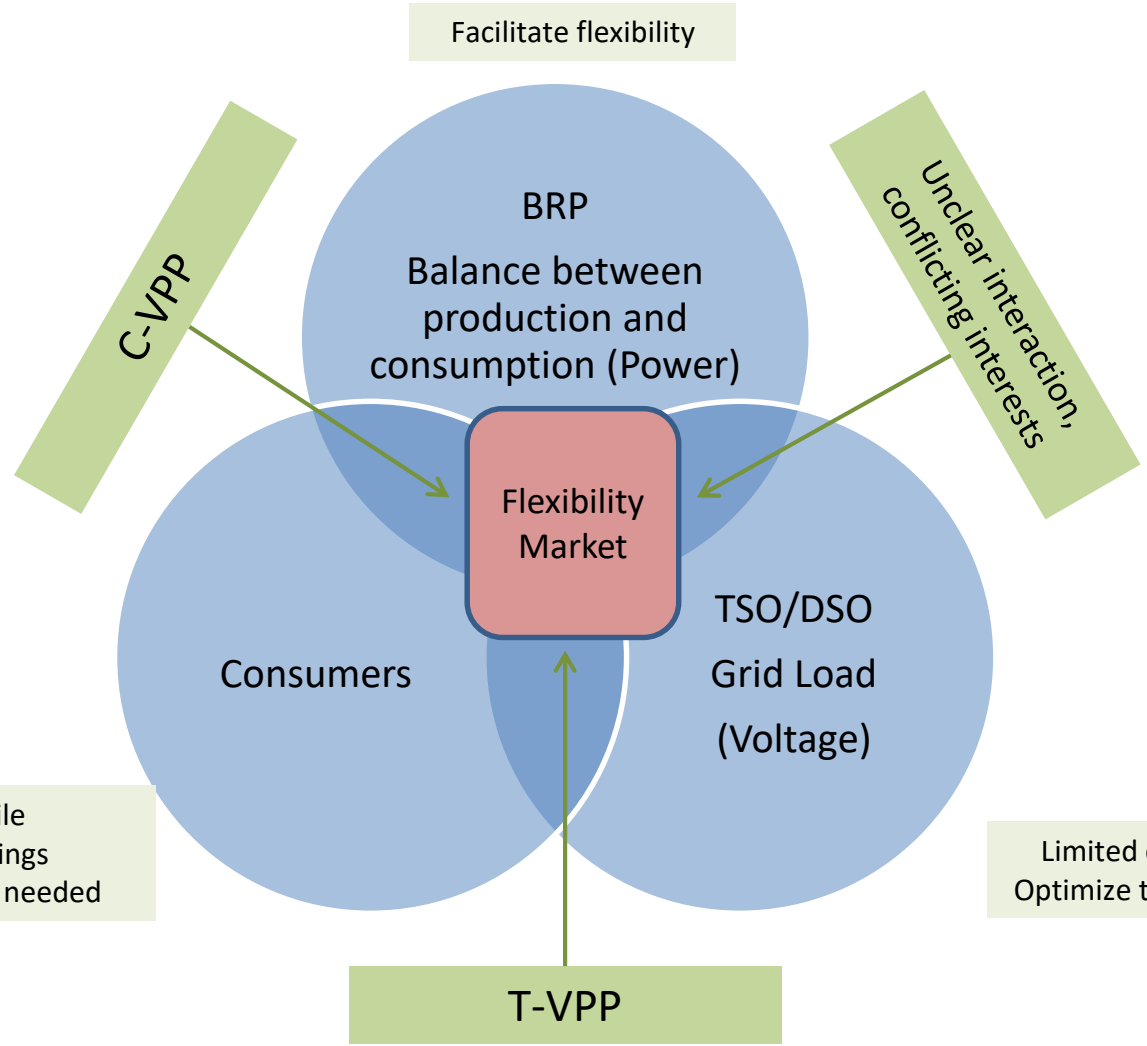
Background - built-in conflict



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Objective

The objective with TotalFlex is to design a flexible, attractive and cost-effective electricity system for *any* size of flexible consumption and production.

- Power customers are rewarded by the highest bidder for the flexibility provided
- The electricity system is better balanced
  - Consumption and production are synchronous
  - Lower prices for system services
- DSO postpones grid reinforcement due to bottlenecks and congestion are avoided

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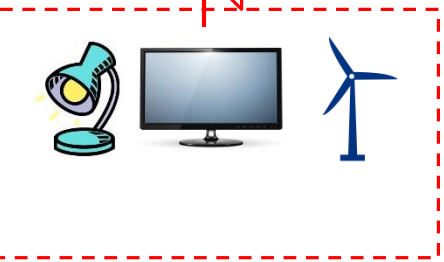
Flex-Offer concept

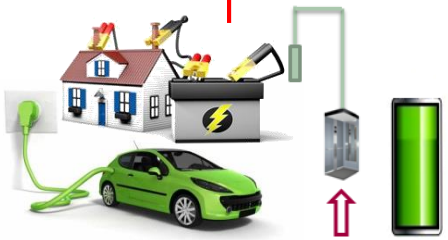
- Flexible Electricity Consumers and Producers

No or simple flexibility patterns → **Complex flexibility patterns**

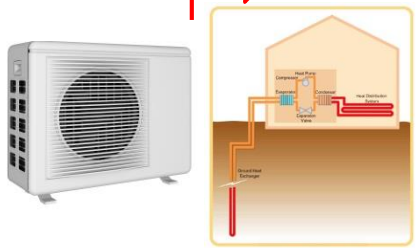


- No flexibility

- *Time-shift* flexibility



- *Time-shift* flexibility
- *Amount* flexibility
- [*Total Amount* requirement]



- Amount flexibility with intra-time unit dependencies

Flexibility Offer (Flex-Offer) allows unified modelling of a flexible consumer/producer in **ALL these cases**

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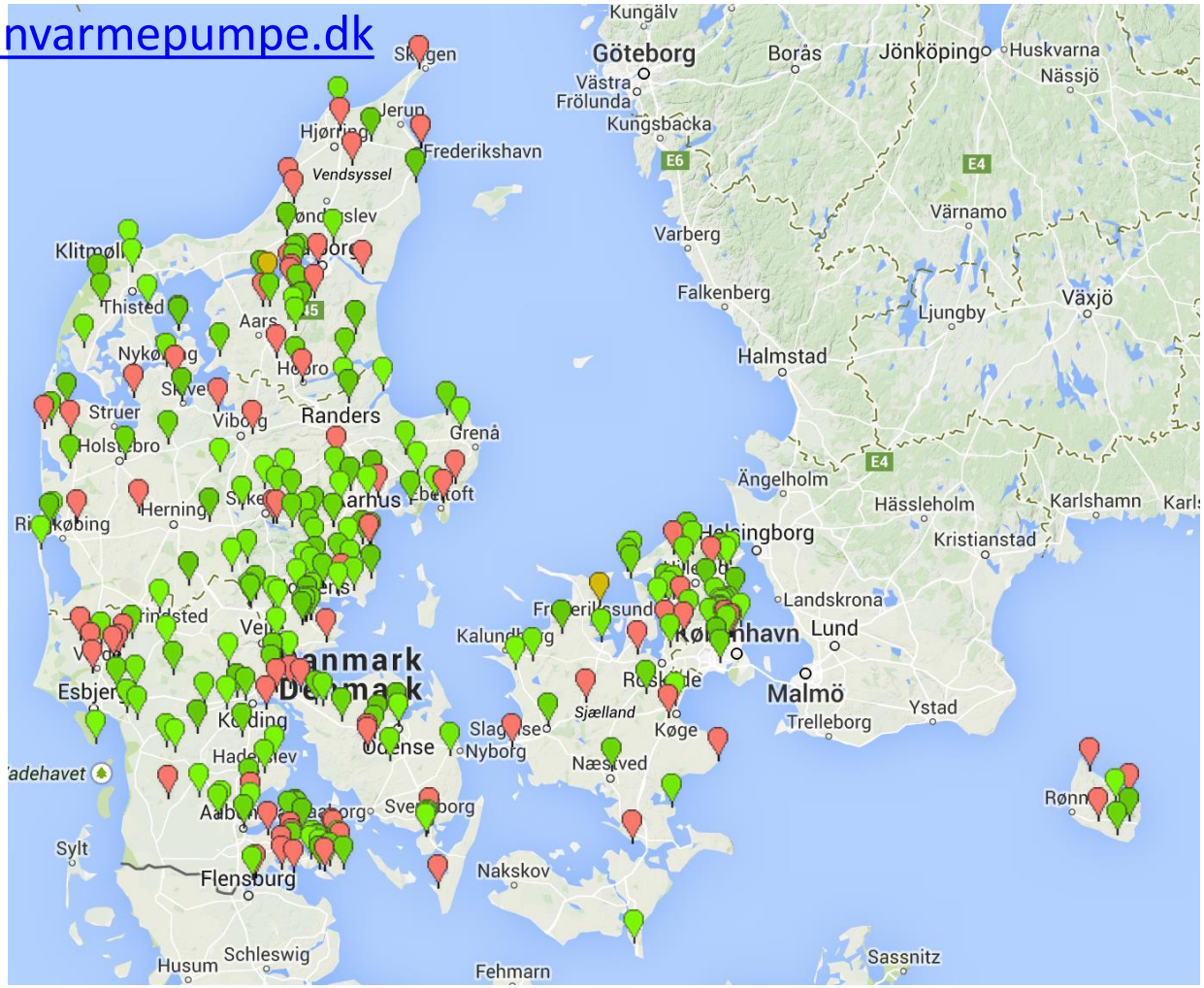
Where is the flexibility?
Heat pump case

www.styrdinvarmepumpe.dk



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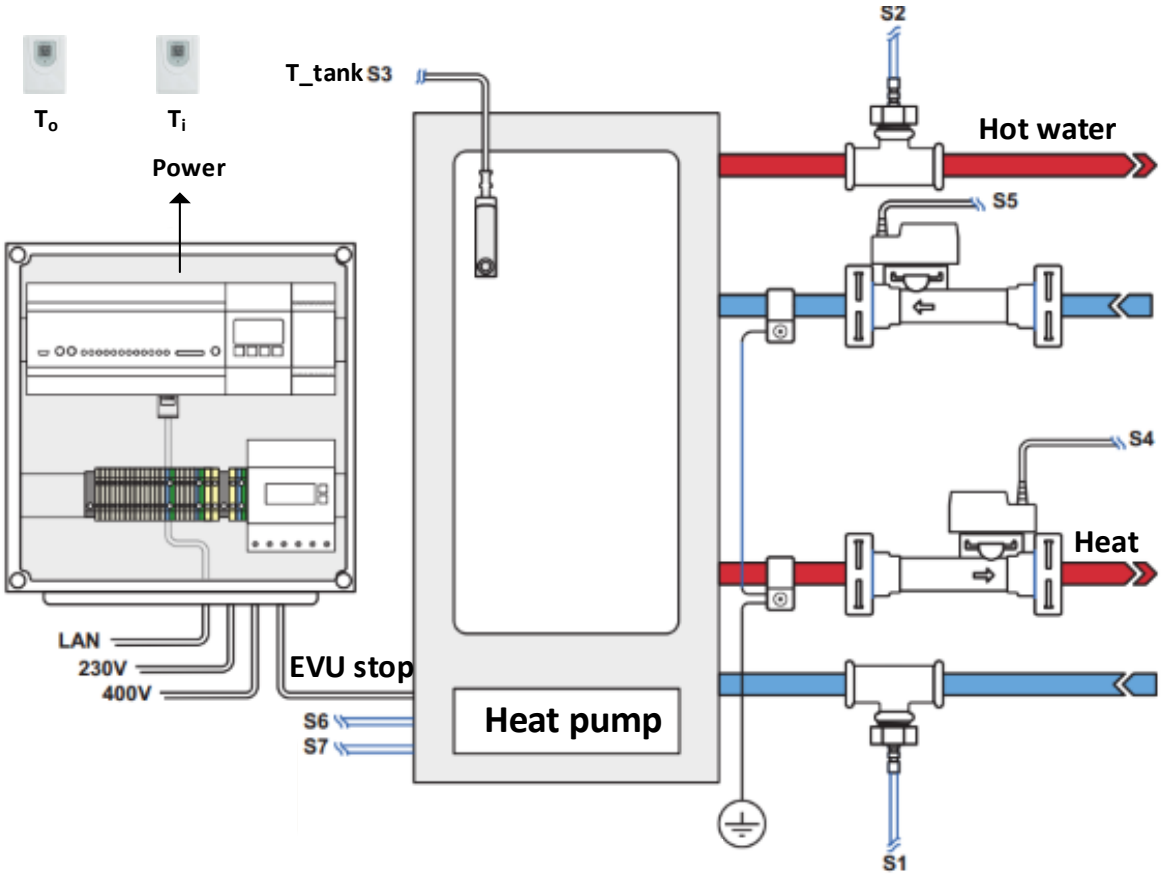
StyrDinVarmepumpe
Heat pump connection



- 300 installations
- 5 minutes resolution

- Controlled via relay input
- Can stop heat pump
- Can not force start
- But allow heat pump to run
- XMPP: online monitoring
- XMPP: online control

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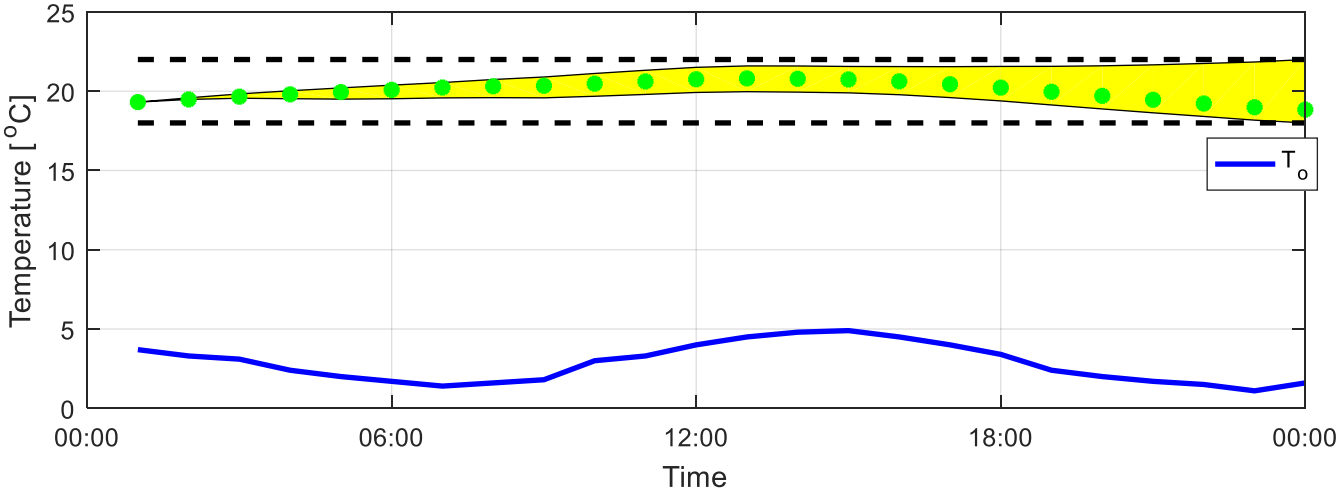
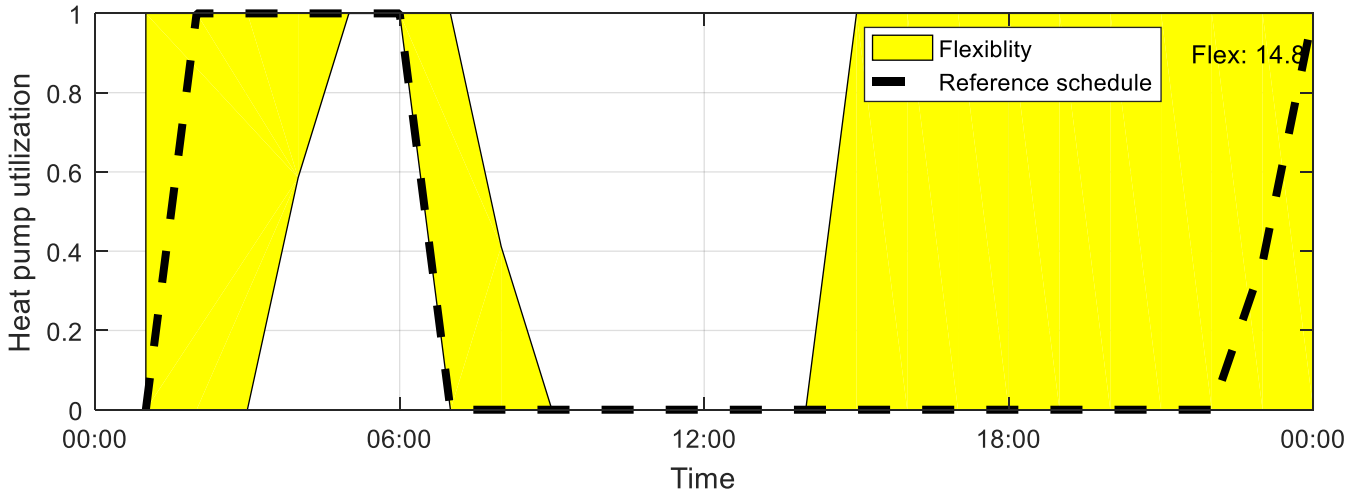
Typcial heat pump flexibility





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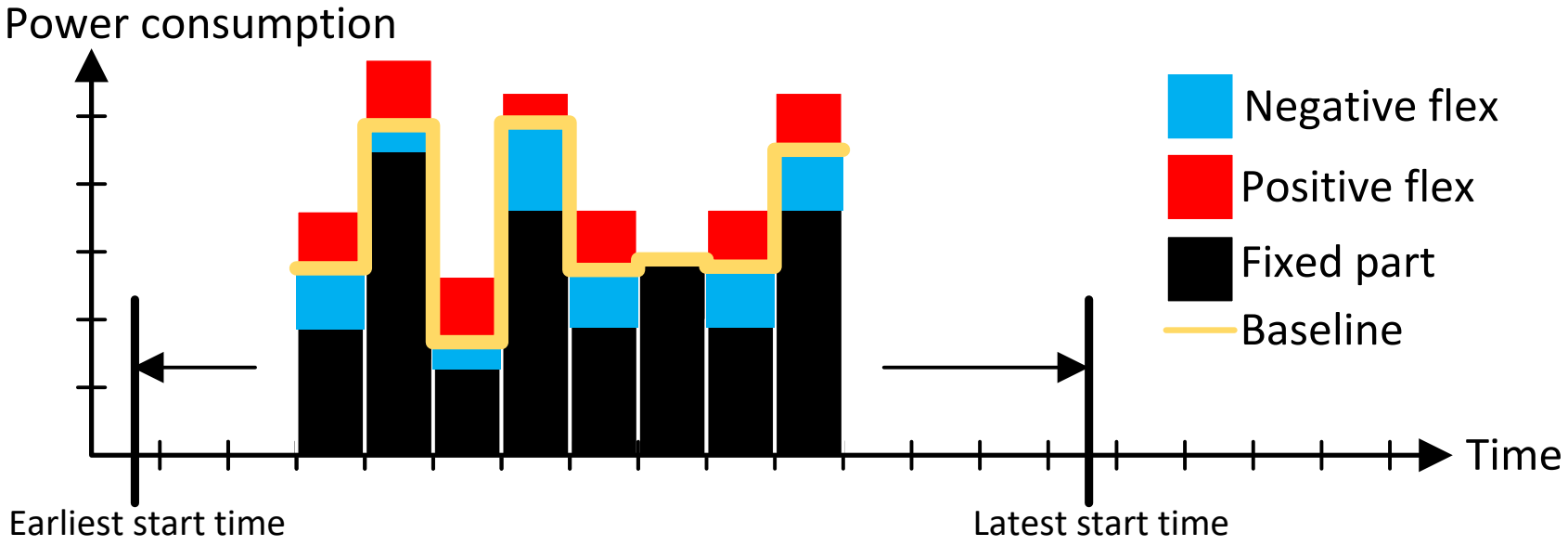
Flex-Offer schedule



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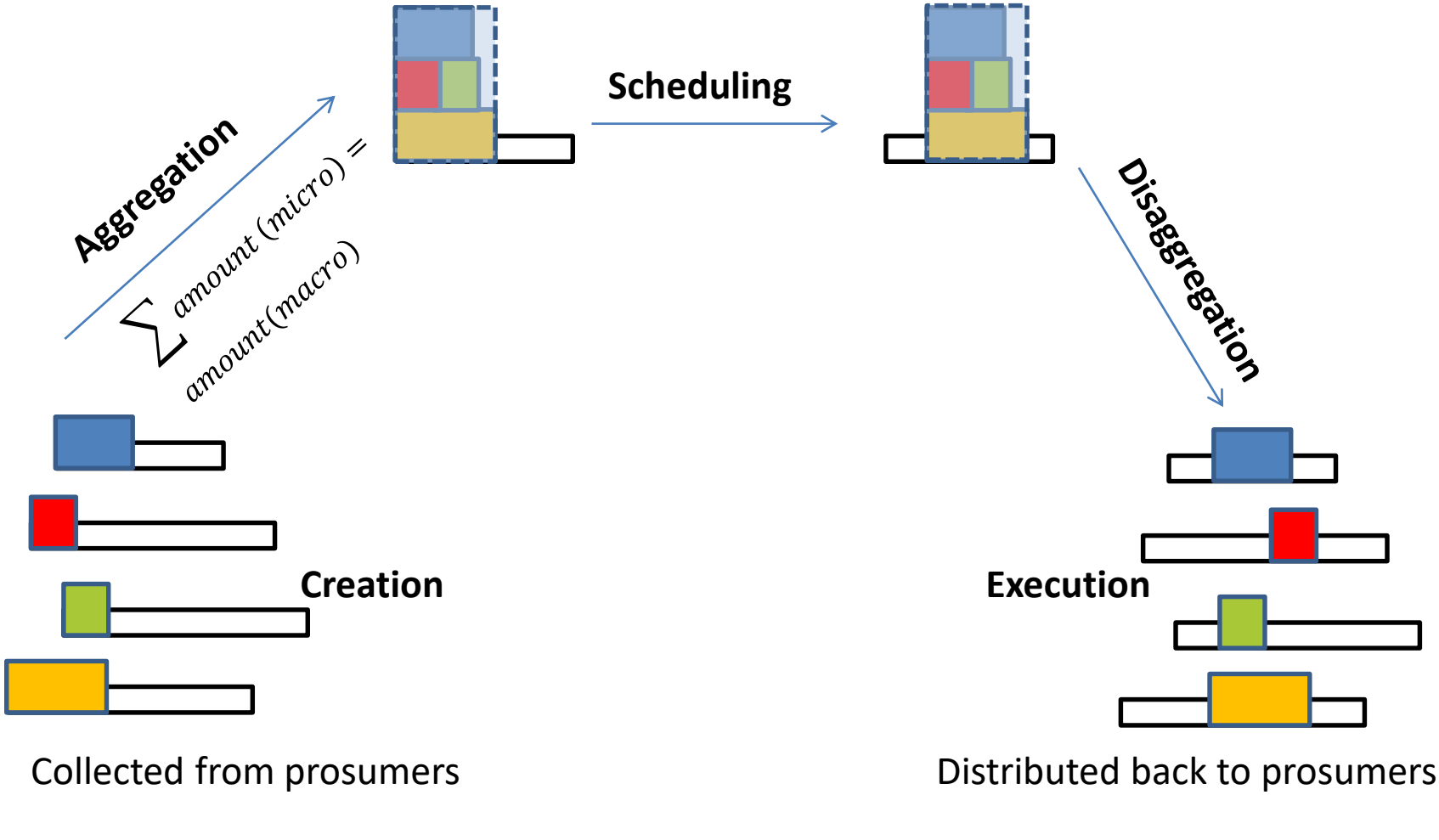
The cycle of Flex-Offer



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Market Place - facts

- What is sold in the marketplace?
  - The right to schedule flexibility
  - Flexibility here and now, next day or over a long period
- What does a marketplace?
  - Finds the highest price to the seller for the offered flexibility
  - No guarantee for "winning"
  - Provides an economic optimum
- Which actors exist (who buys and sells?)
  - Electricity customers through aggregators
  - Balance responsible parties with access to existing energy markets
  - DSOs
  - TSOs
  - …
- All flexible resources are direct controlled, not price controlled

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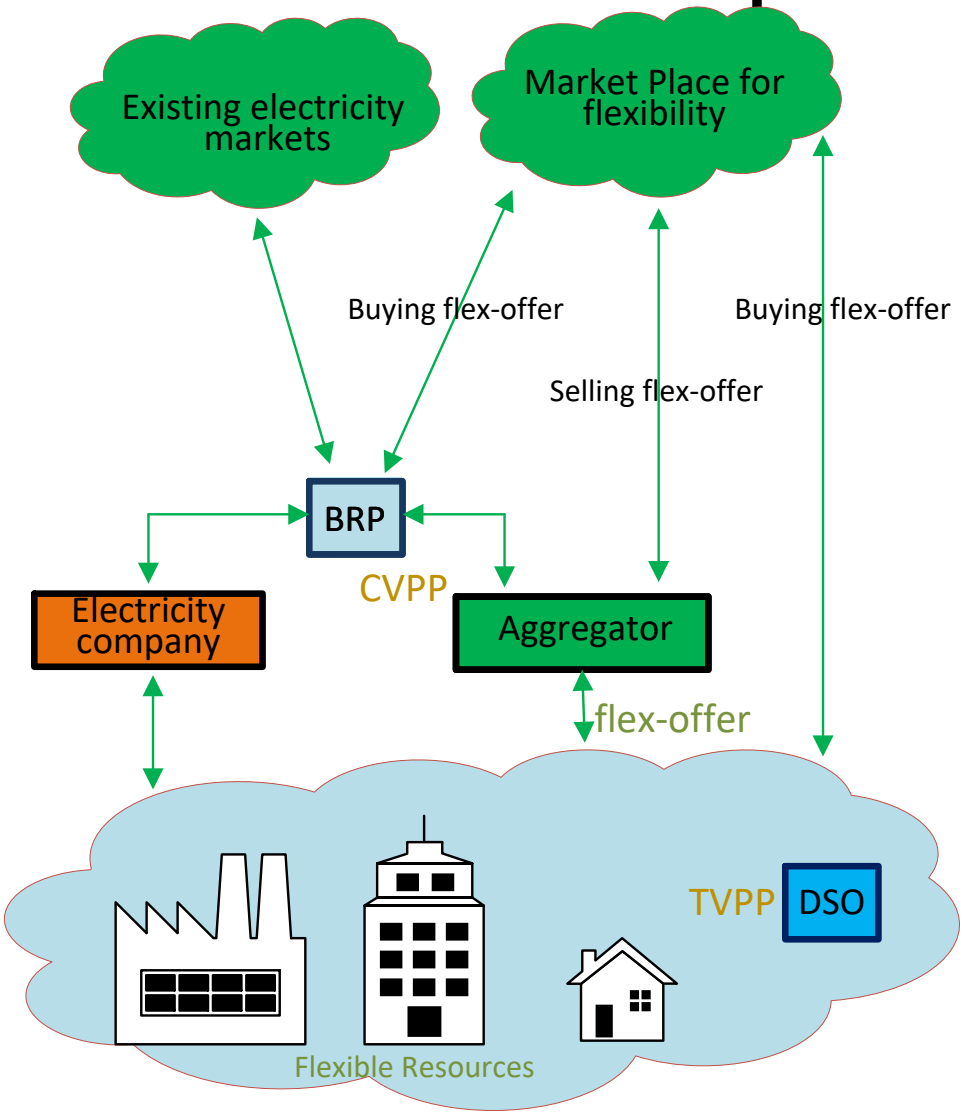
Market Place – simplified



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Market Place

- TotalFlex supports existing electricity phases today:
  - Future markets
  - Day ahead
  - Intra hour

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Market Place – Actors and their motivations

- Prosumers, owners of flexible resources
  - Much flexibility can be utilized without loss of comfort
  - Future heat pumps and EVs are Smart Grid Ready
  - No markets for small amounts of flexibility today
- Aggregator
  - Specializes in specific types of consumption and production
  - Aggregates Flex-Offers to fit various markets
  - Flexibility sales price should cover:
    - Contract with prosumer
    - Operation and transaction cost
    - Potential imbalance cost
    - Own earning

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Market Place
Actors and their motivations

- DSO
  - Reducing bottlenecks (LV / MV) rather than grid reinforcement
  - Can enter both long and short term agreements
  - Alternative to bilateral agreement
  - The Market Place offer no guarantee of getting a product home
- BRP
  - Reduce internal imbalances
  - Intra-hour Flex-Offers can be used in the regulating power market

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Market Place pricing

- How is the Market cleared?
  - Mixed Integer Linear Programming (MILP) formulation
    - One price per timeslot per kWh
  - Maximise social surplus
    - Activate “Lowest buying price” and “highest sales price” first
  - It is possible to sell the partial quantities of a product
  - Closed anonymous auction
  - Fixed price per unit from each buyer and seller in each time slot
  - Only activated in one direction per time slot
  - Supported constraints so far:
    - Max/min/specific amount across time slots
    - Flex-Offer belonging to an electricity area, i.e. low voltage radial
    - Flex-Offer belonging to a specific BRP
    - Minimum activation amount per timeslot (i.e. regulating power market)

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Market Place clearing - math

- Market clearing with N timeslots and K buyers and J sellers:

$$min \quad \sum_{i=1}^{N}\sum_{k=1}^{K} p_k^b |q|_{i,k}^b - \sum_{i=1}^{N}\sum_{j=1}^{J} p_j^s |q|_{i,j}^s$$

$$subject\ to$$

$$\sum_{k=1}^{K} q_{i,k}^b = \sum_{j=1}^{J} q_{i,j}^s \text{ , for negative and positive part separately}$$

$$q_{min,i,j,k} \leq q_{i,j,k} \leq q_{max,i,j,jk}$$

$$q_{min,i,j,k} \leq 0, \quad q_{max,i,j,k} \geq 0$$

$$p_{min,i,k} \geq p_{max,i,j}$$

BRP constraints

Geograhical area constraints

$p_{i,k}^b, p_{i,j}^s$ unit price from the k[th] buyer and j[th] seller respectively for the activated flexibility for i[th] timeslot

$q_{i,k}^b, p_{i,j}^s$ buying and selling activated flexibility relative to reference from the k[th] buyer and j[th] seller for i[th] timeslot

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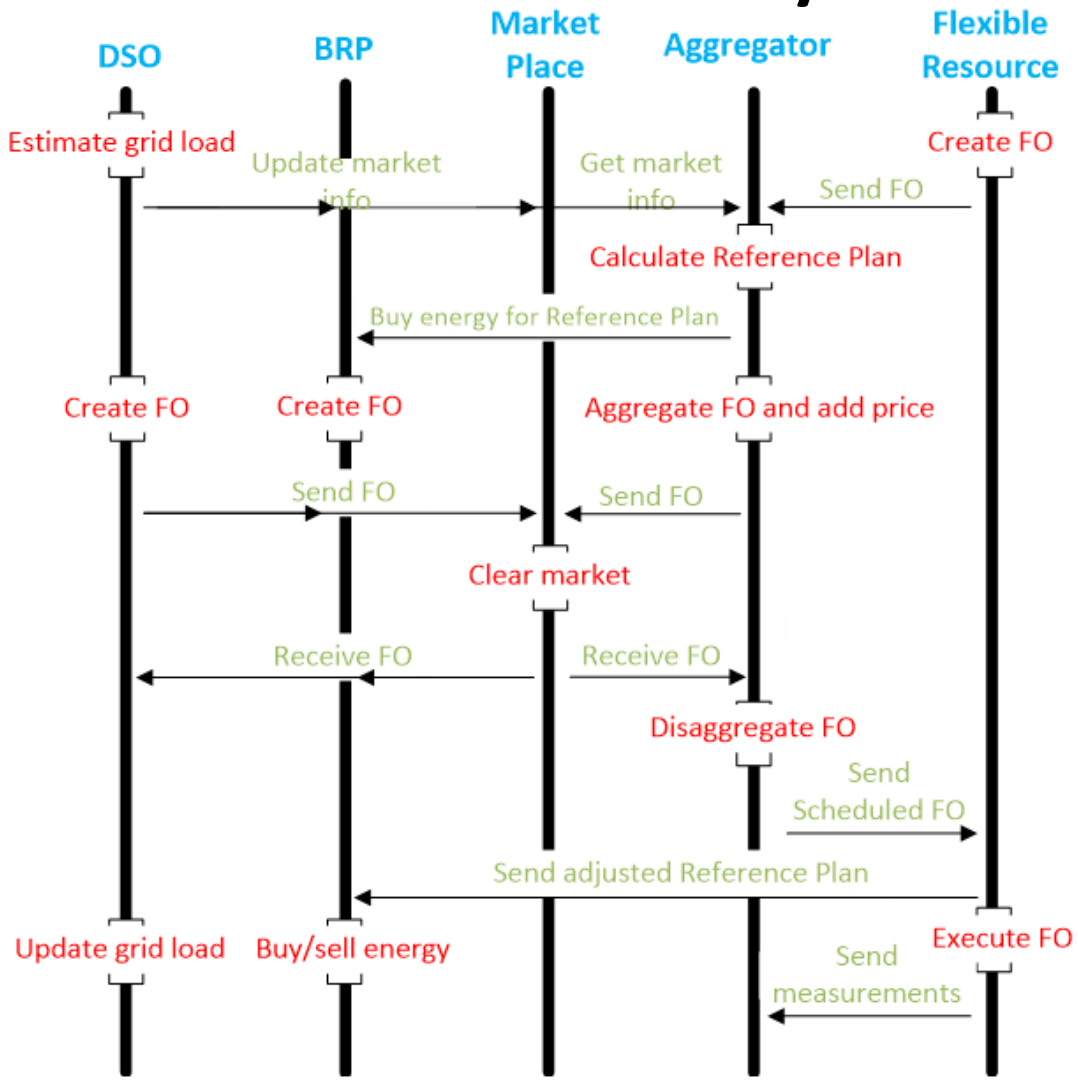
Market Place - Day ahead



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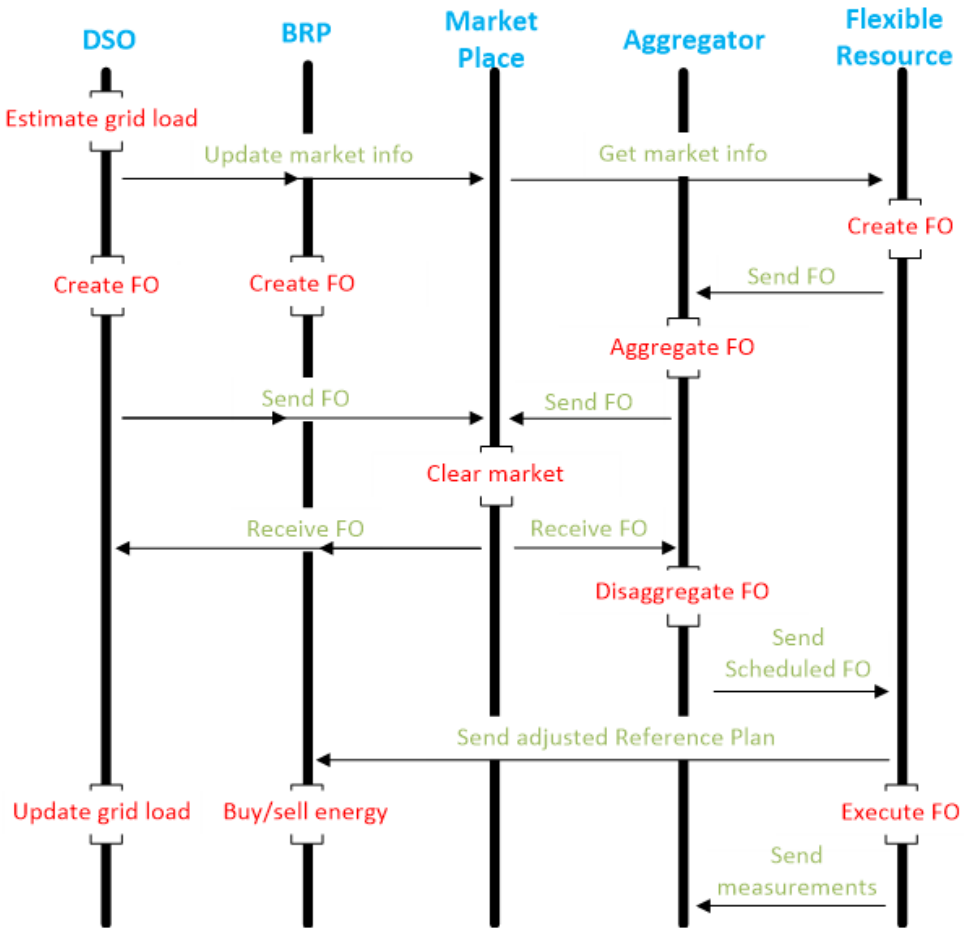
Market Place - Intra hour



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Market Place example

Flex-offers with price info on the market

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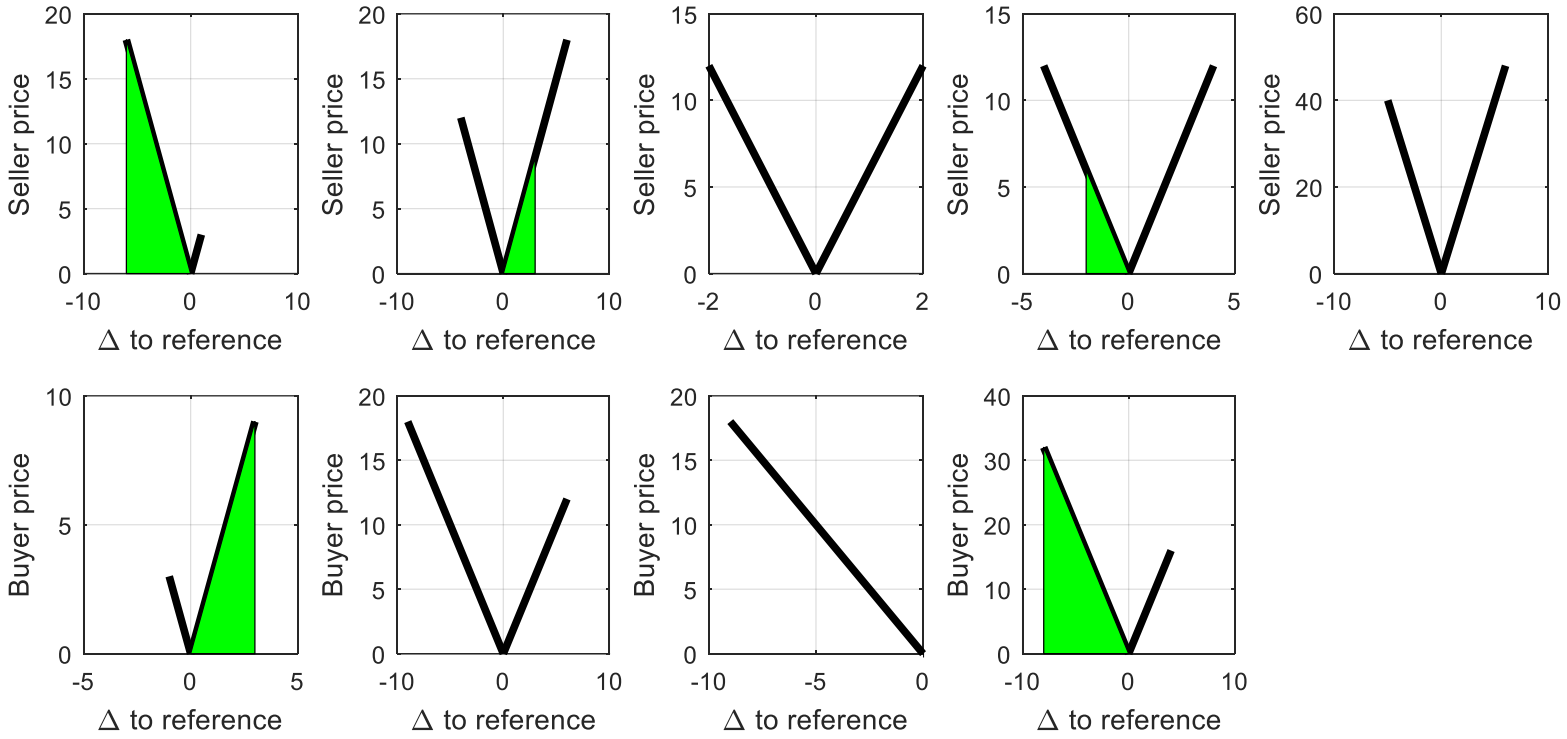
Market Place example

Linear price/quantity relationship assumed



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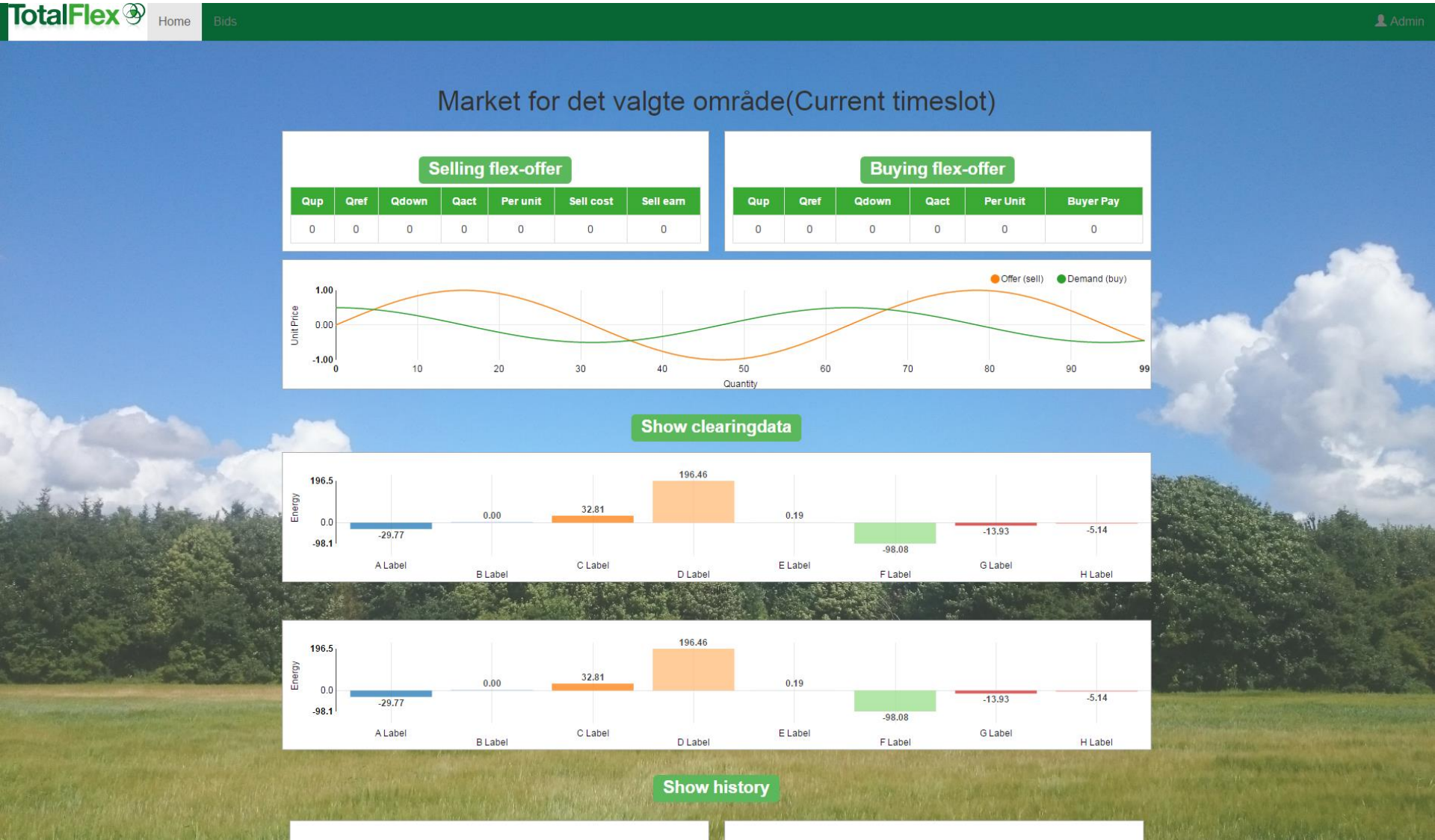
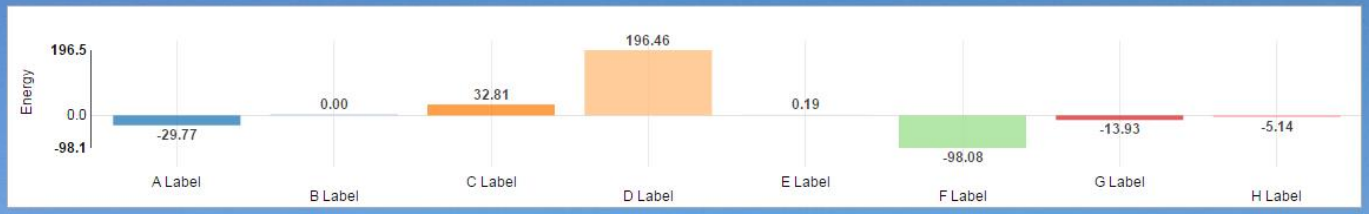
TotalFlex GUI

TotalFlex GUI



TotalFlex GUI

TotalFlex Home Bids



Show history

Selling flex-offer

Timeslot	Min. Energy (MW)	Max. Energy (EUR/MW)	Ref. Energy	Price per unit	Fixed price
11	1,837.761	1,581.59	0	0	0
11	1,901.304	1,699.67	0	0	0
13	1,752.151	1,999.09	0	0	0
12	1,965.335	1,464.76	0	0	0
11	1,667.065	1,781.34	0	0	0
12	1,753.920	1,441.24	0	0	0
12	1,451.293	1,759.16	0	0	0
8	1,416.489	1,179.34	0	0	0
9	1,404.430	1,127.82	0	0	0
9	1,364.484	1,076.09	0	0	0
19	3,210.833	2,631.94	0	0	0

Buying flex-offer

Timeslot	Winning	Energy (EUR/MW)	Price
11	1,837.761	1,581.59	0
11	1,901.304	1,699.67	0
13	1,752.151	1,999.09	0
12	1,965.335	1,464.76	0
11	1,667.065	1,781.34	0
12	1,753.920	1,441.24	0
12	1,451.293	1,759.16	0
8	1,416.489	1,179.34	0
9	1,404.430	1,127.82	0
9	1,364.484	1,076.09	0
19	3,210.833	2,631.94	0

TotalFlex - end status

- A market-based trading system for flexibility has been demonstrated
  - Aggregators are sellers and DSO and BRP are buyers
- Total Flex shows a path where small electricity customers can benefit from their flexibility
- Total Flex fits in Market Model 2.0 work
- The following functionality is developed:
  - Data collection from flexible resources
  - Generation, aggregation of Flex Offers
  - Clearing the Market
  - Disaggregation of scheduled Flex-Offers
  - Execution of Flex-Offers to control the flexible resources
- TVPP, IT tool to DSO for simple monitoring and prediction of bottleneck locations
- CVPP, IT management tool Flex Offers
- Marketplace, which can coexist with existing markets

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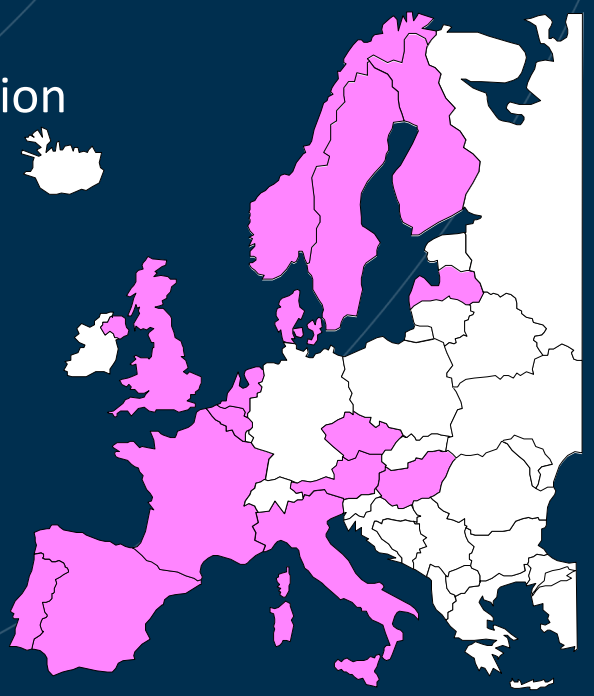
Arrowhead

Process and energy system automation



4 years project
68M€
78 partners
Coordinated by

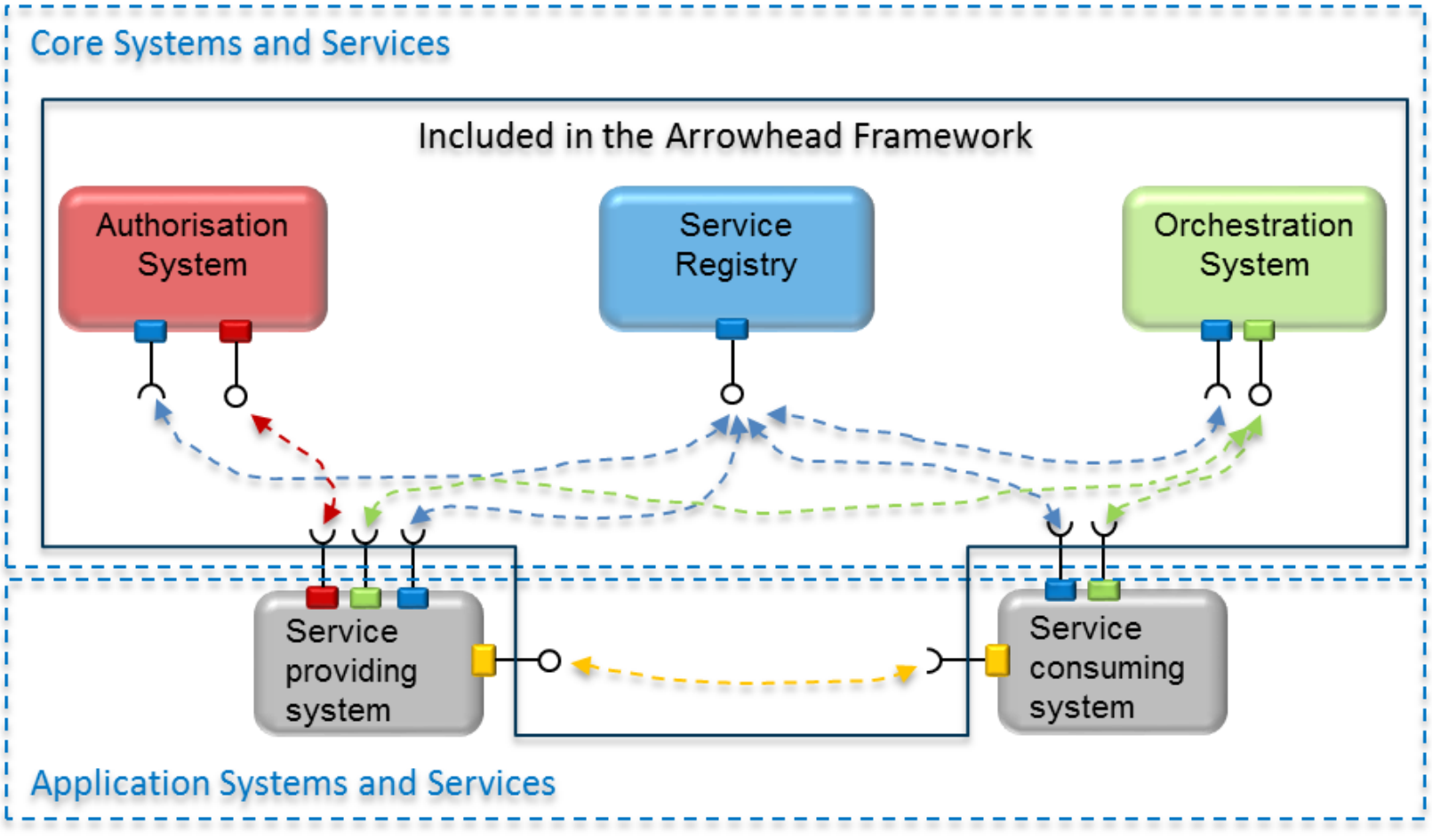
processit.eu
Automation for process industries

an ARTEMIS CoIE

www.arrowhead.eu - jerker.delsing@ltu.se

ARROWHEAD

Arrowhead
IoT architecture



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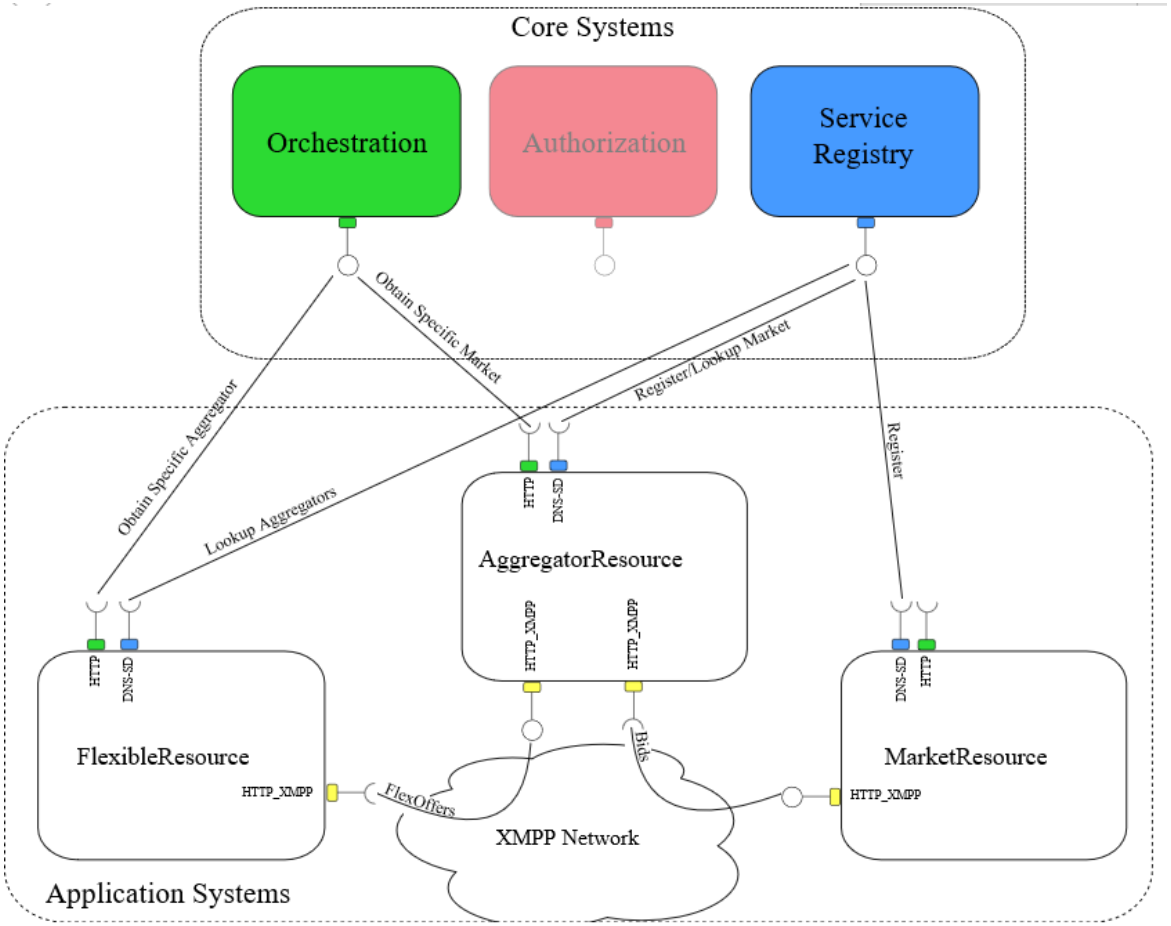
Arrowhead SoA framework



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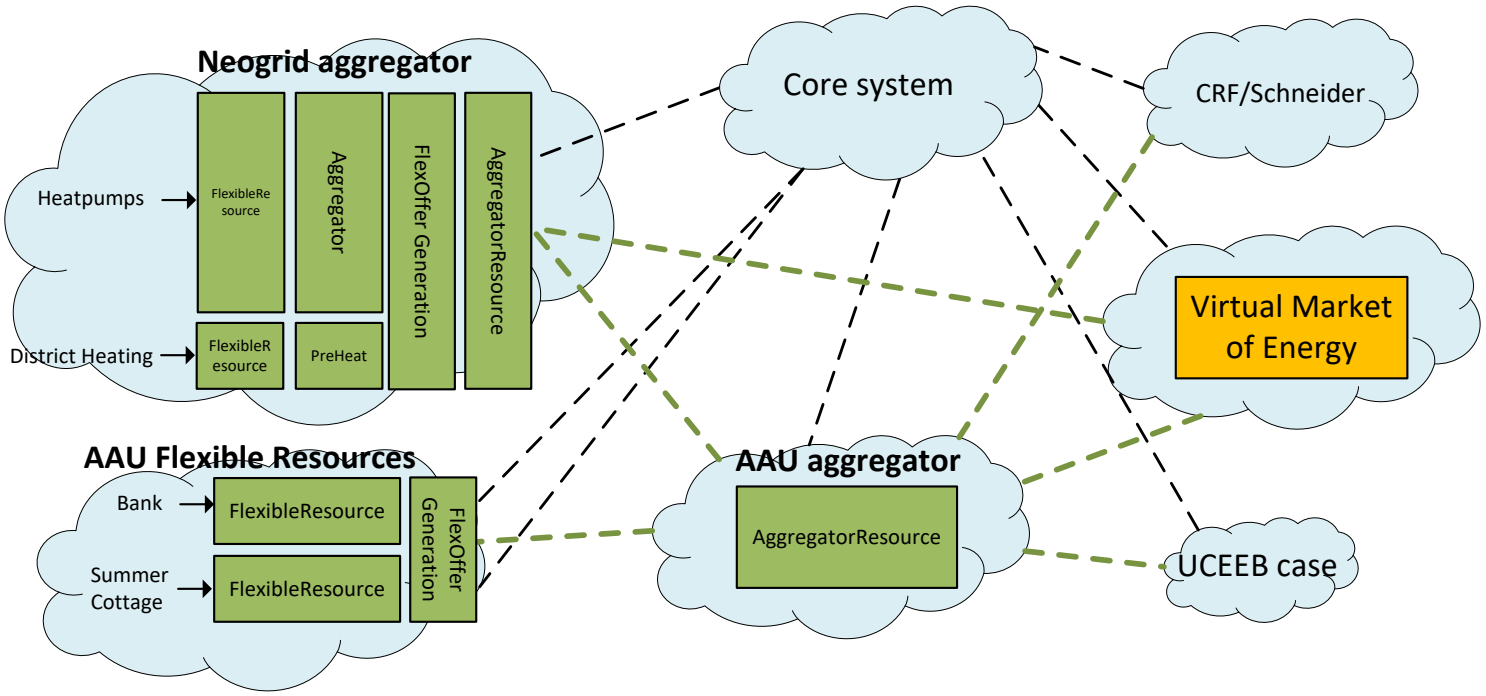
Demonstration setup



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? Questions

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