Open source tools for integrated operation and planning of flexible buildings and distribution network

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Content

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- Concept of grid side modules
  - Long-term planning
  - Short-term operations
  - Overview of 3Smart platform
- Conclusion

Smart building - Smart Grid – Smart City (3Smart)

Current State Analysis in the Danube Region

REGULATORY

- Diverse levels of liberalization of power markets in different countries
- Diverse stances towards smart meter roll-outs
- Cooperation and information exchange between TSOs and DSOs in the context of flexibility-based services are limited
- Dynamic prices are not offered to the end consumers in many countries hence hindering utilization of enduser flexibility

DSO

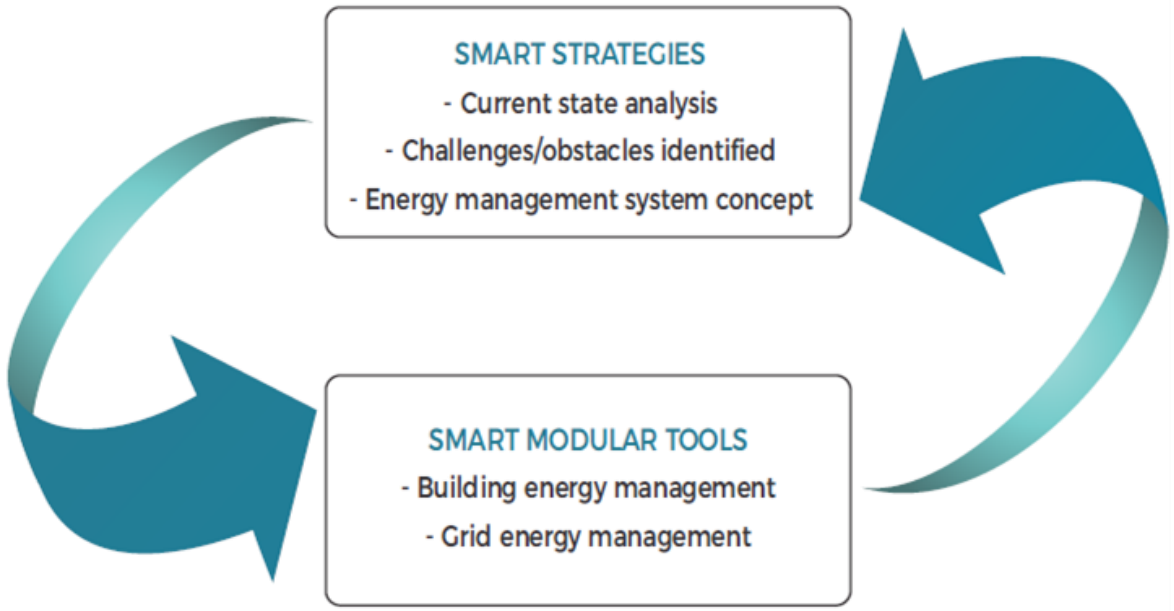
- Deep connection cost for DER integration might result in overbuilding and underutilizing the distribution network assets
- Optimal network layout/topology is based on experience and rarely changed
- Storage is mainly not recognized as a DSO asset
- Long-term network planning strategies, such as reducing the number of voltage levels, need to be integrated with smart distribution network planning concepts
- Conflicting challenges between standardizing procedures for planning future distribution networks and continuous integration of new technologies

TECHNOLOGY

- Diverse energy markets mechanisms
- Smart meter roll-out carried out only in a few countries
- Missing international and national technological guidelines for building energy management systems
- Currently technical specifications of smart meters deployed by DSOs do not cover possibility of communication with building energy management systems
- Highly skilled experts are needed for installation of building energy

3Smart goals

- To provide a technological and legislative setup for cross-spanning energy management of buildings, energy grids and major city infrastructures in the Danube region.
- This includes the development of a **modular platform for coordinated building and distribution grid energy management.**
- The developed platform is installed on 5 pilot locations in 5 countries



Grid side modules

Advance Energy Management Concept

Transition from passive to advance energy management:

- DERs are consider as flexibility service provider to DSO
- Coordinated grid-building operation

Benefits:

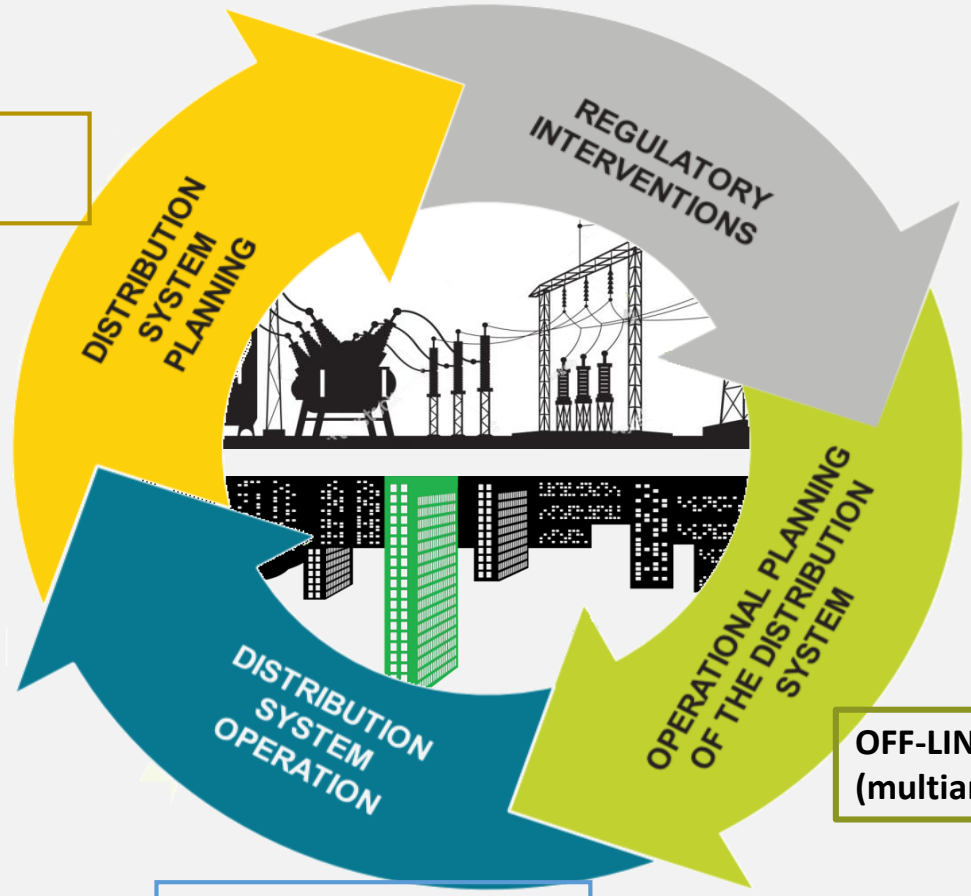
- Mitigating voltage peaks/sags,
- Reducing power losses
- Improving reliability and quality of supply

FLEXIBILITY SERVICE PROVIDER CHARACTERISTICS

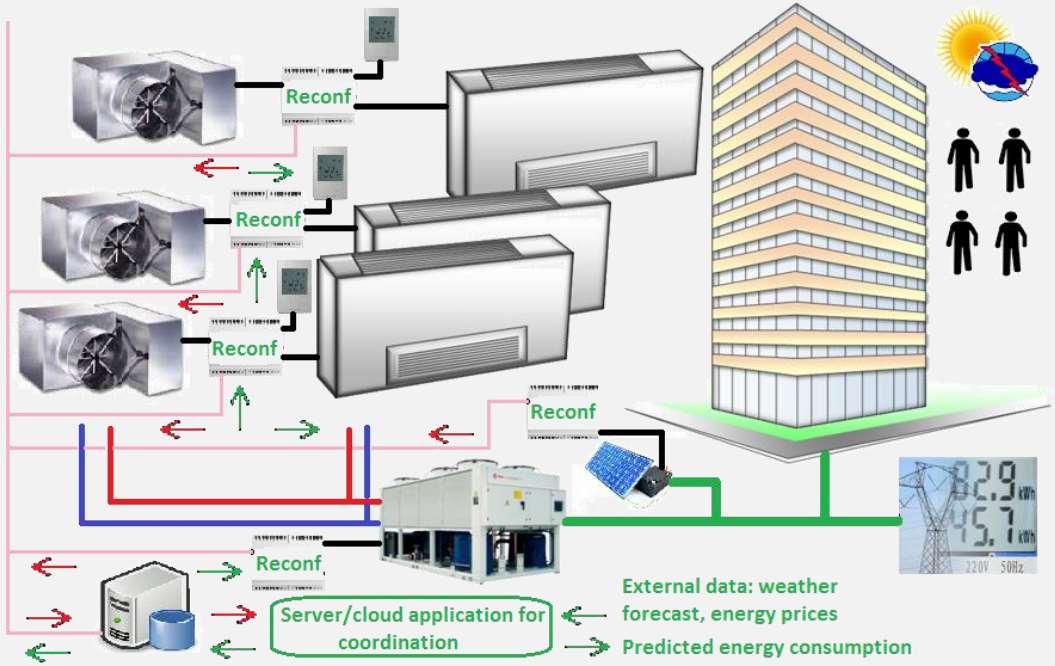
- Buildings with implemented energy management system (BEMS)
- Multi-level model predictive control
- The microgrid level
  - Interconnects with grid- side operations
  - Controls charging/ discharging of the energy storage system

Grid-side Modules Coordination

OFF-LINE
(multiannual)



ON-LINE
(day-ahead, intra-day)



OFF-LINE
(multiannual)

Long-term Module (Offline)

Annual module

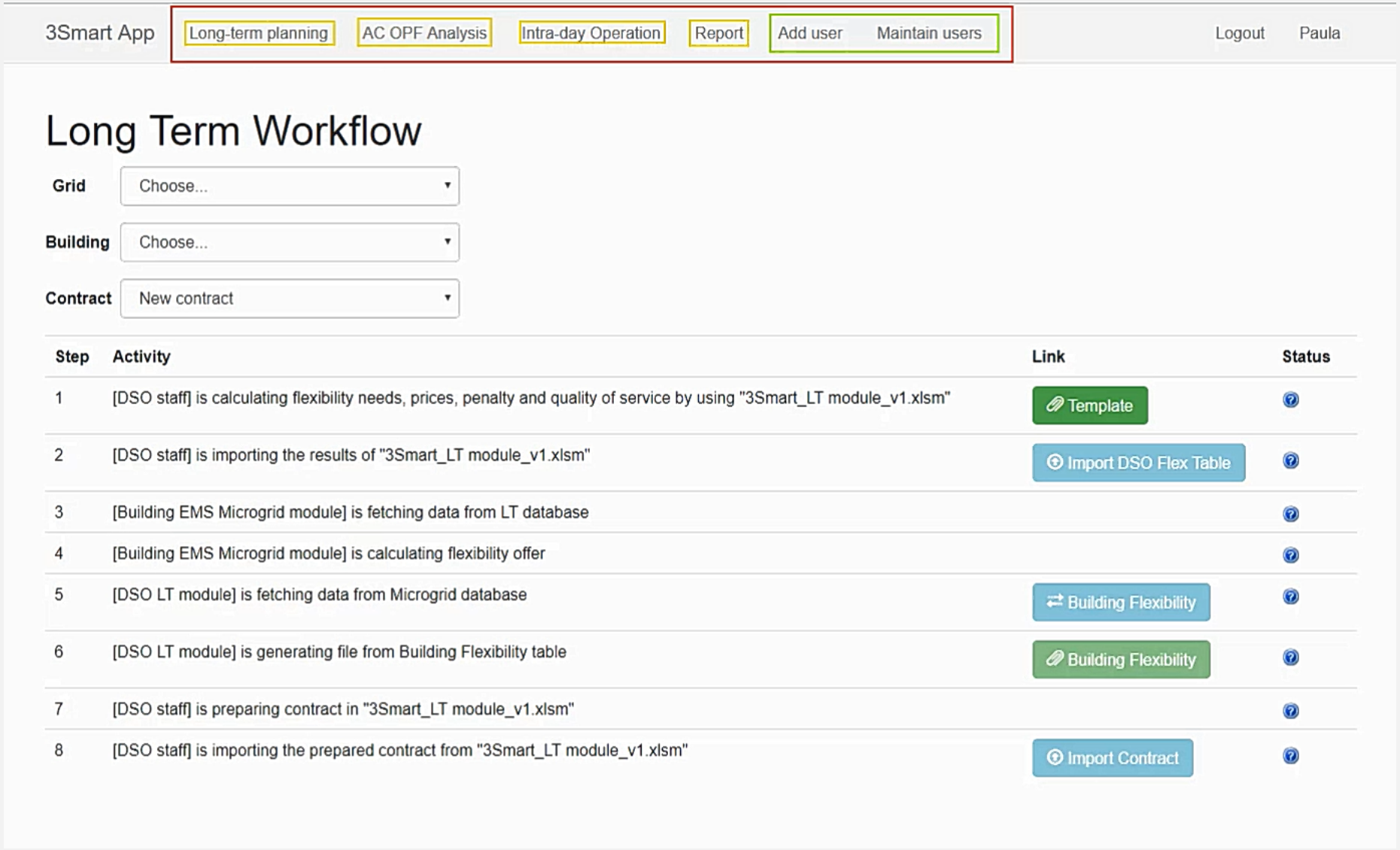
- Network operation simulations
- Determining flexibility window

(time and the volume of flexibility)

Multiannual module

- Calculation of free amount of money for flexibility services
- Based on postponing network reinforcement investment
- Financial analysis (WACC, inflation)
- Results in reservation and activation prices and penalties for not providing the contracted services

3Smart Platform – Long-term module



3Smart Platform – Long-term module (2)

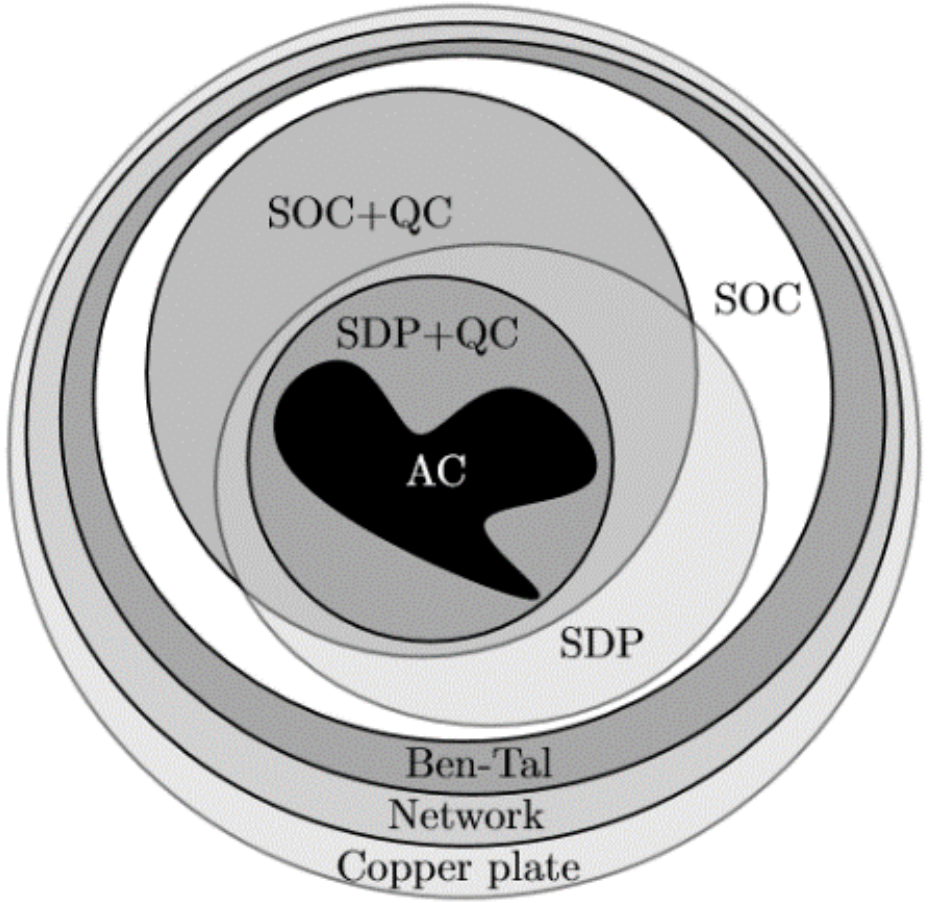
	A	B	C	E	F	G	H
2	Month	Type of day	Flexibility requirement [kW]	Time interval (Start)	Time interval (Length)	Flexibility requirement [kWh]	Pcs of type of days
3	2019-01	WEEKDAYS	-11.38	11:30	3.50	-39.83	22
4	2019-02	WEEKDAYS	-11.38	11:30	3.50	-39.83	20
5	2019-06	WEEKDAYS	-23.22	10:30	0.50	-11.61	17
6	2019-06	WEEKDAYS	-23.22	11:30	0.25	-5.81	
7	2019-06	WEEKDAYS	-73.63	13:00	0.50	-36.82	
8	2019-06	WEEKDAYS	-73.63	14:30	0.50	-36.82	
9	2019-07	WEEKDAYS	-23.22	10:30	0.50	-11.61	
10	2019-07	WEEKDAYS	-23.22	11:30	0.25	-5.81	
11	2019-07	WEEKDAYS	-73.63	13:00	0.50	-36.82	
12	2019-07	WEEKDAYS	-73.63	14:30	0.50	-36.82	
13	2019-08	WEEKDAYS	-23.22	10:30	0.50	-11.61	
14	2019-08	WEEKDAYS	-23.22	11:30	0.25	-5.81	
15	2019-08	WEEKDAYS	-73.63	13:00	0.50	-36.82	
16	2019-08	WEEKDAYS	-73.63	14:30	0.50	-36.82	
17	2019-12	WEEKDAYS	-11.38	11:30	3.50	-39.83	
18					0.00	0.00	
19					0.00	0.00	
20					0.00	0.00	
21					0.00	0.00	
22					0.00	0.00	
23					0.00	0.00	
24					0.00	0.00	
25					0.00	0.00	
26					0.00	0.00	
27					0.00	0.00	
28					0.00	0.00	
29					0.00	0.00	
30					0.00	0.00	

Untitled project

	A	B	C
1	**Caclulation of flexibility resource**		
2	WACC	4.00%	
3	Inflation	2.50%	
4	The cost of investment	120,360	EUR
5	Ratio of used flexibility price	100%	
6	Year	2019	2020
7	WACC	4.0%	4.0%
8	Inflation	2.5%	2.5%
9	FV (Future Value)	120,360	123,369
10	Cost of Investment (with consideration of inflation)	120,360	123,369
11	Minimum amount of money available to cover the future investment	118,624	121,590
12	Maximum price of flexibility	1,736	1,779
13	**Used price of flexibility (maximum*ratio)**	1,736	1,779
14	Free amount of money after flexibility price	118,624	121,590
15	Unused source	0	0
16	**Calculation of unit prices**		
17	Reservation ratio	50.0%	
18	Penalty price multiplicator	2	
19	**Reservation part of Flexibility unit price**	0.027	EUR/kW/(15min)
20	**Activation part of Flexibility unit price**	0.109	EUR/kWh
21	**Penalty**	0.219	EUR/kWh
22	**Quality threshold (max. devviation in size of service without penalty)**	-10	%
23			

Short-term Day-ahead Module (Online)

- Day-to-day operations
- The first way of utilizing the contracted flexibility in the long-term module
  - Optimization is based on convex relaxation model
  - Cost function: power loss minizations
  - Optimizes load flows for next day operation



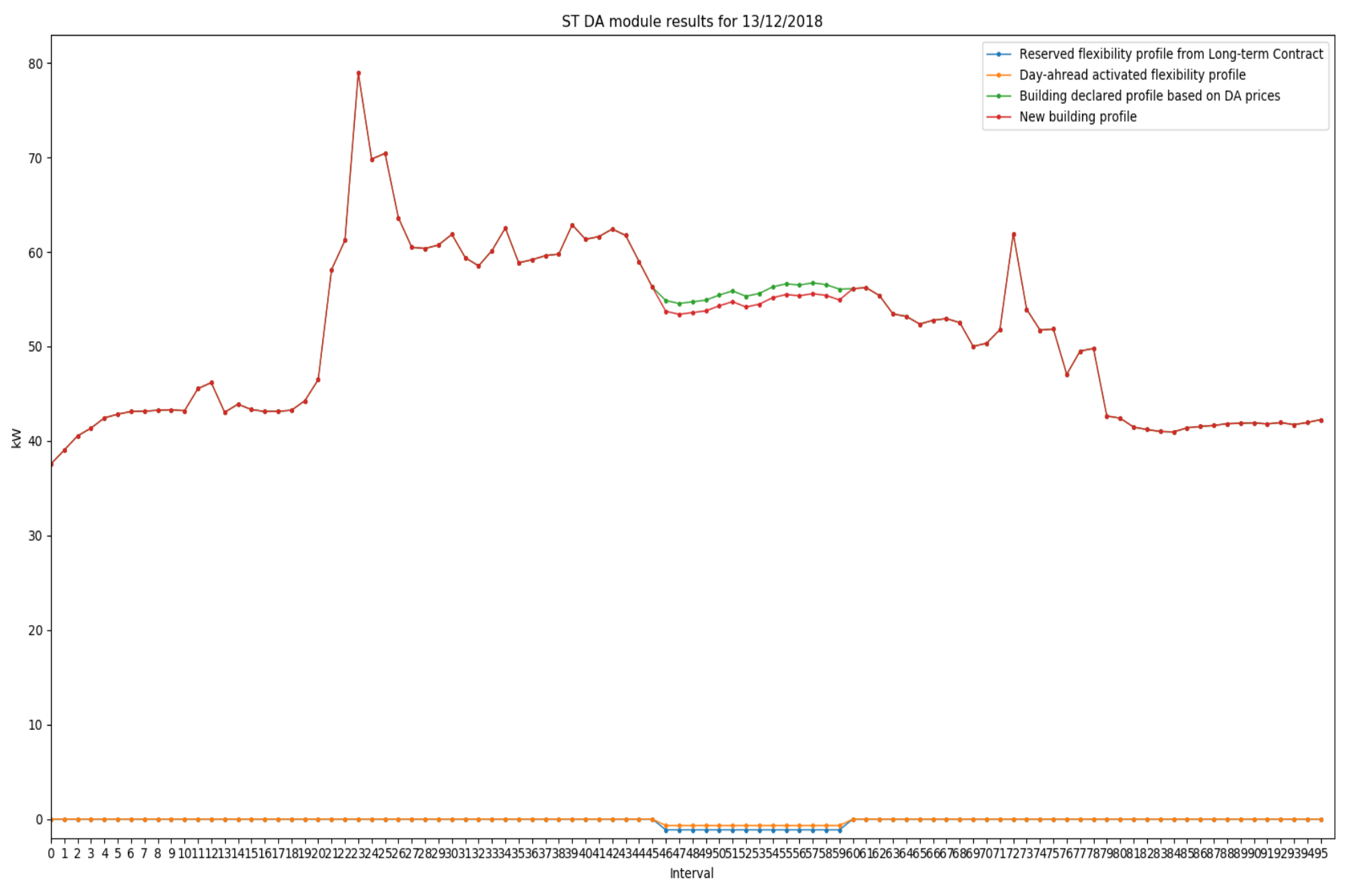
Short-term Day-ahead Module (Online)

Module inputs:

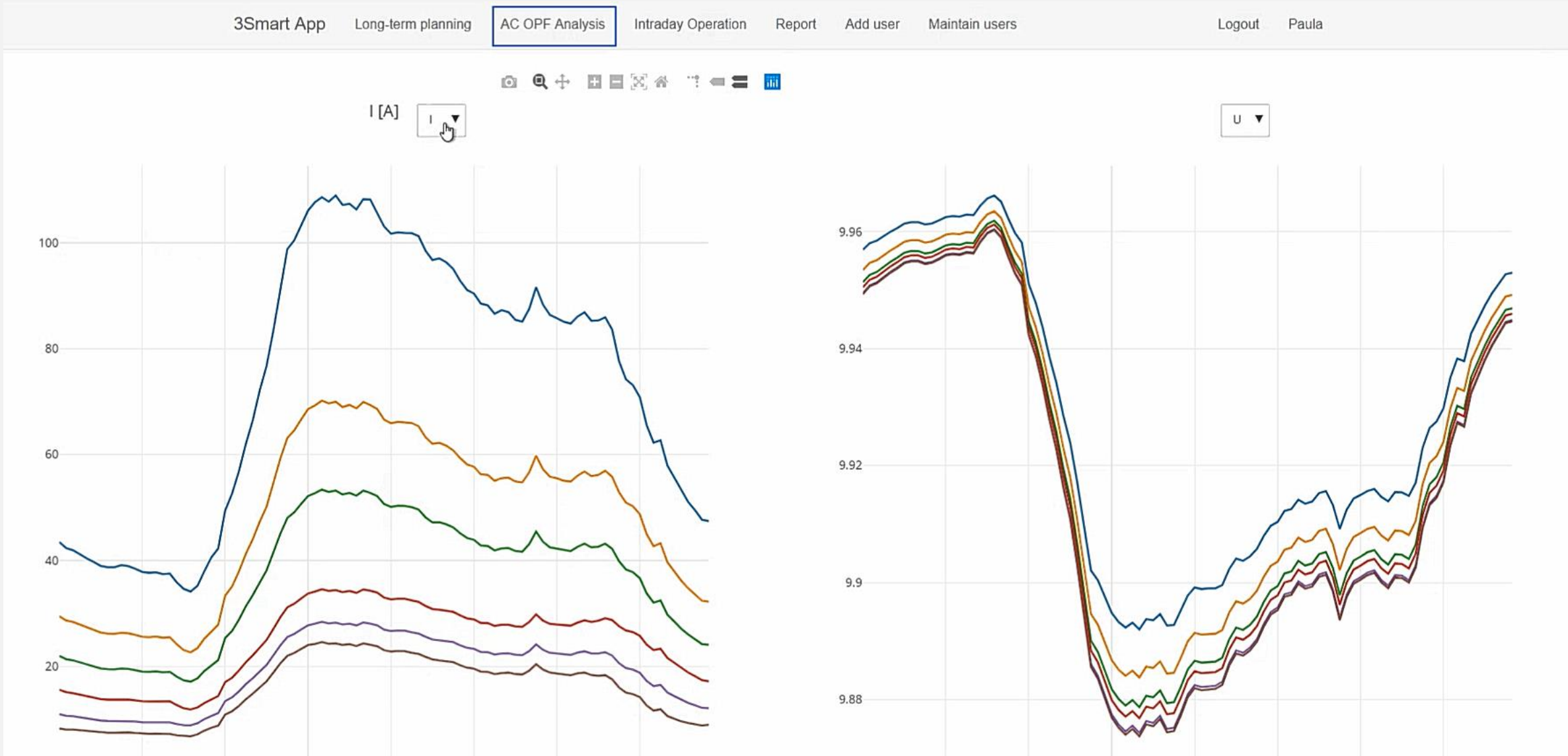
- Grid data
- Load profiles predictions
  - DSO predictions
- Flexibility reservations
- Building predictive load profile

Model outputs:

- Current and voltage state of network
- Building activation flexibility profile


ST DA module results for 13/12/2018
Reserved flexibility profile from Long-term Contract
Day-ahread activated flexibility profile
Building declared profile based on DA prices
New building profile
kW
Interval

3Smart Platform – Day-ahead module



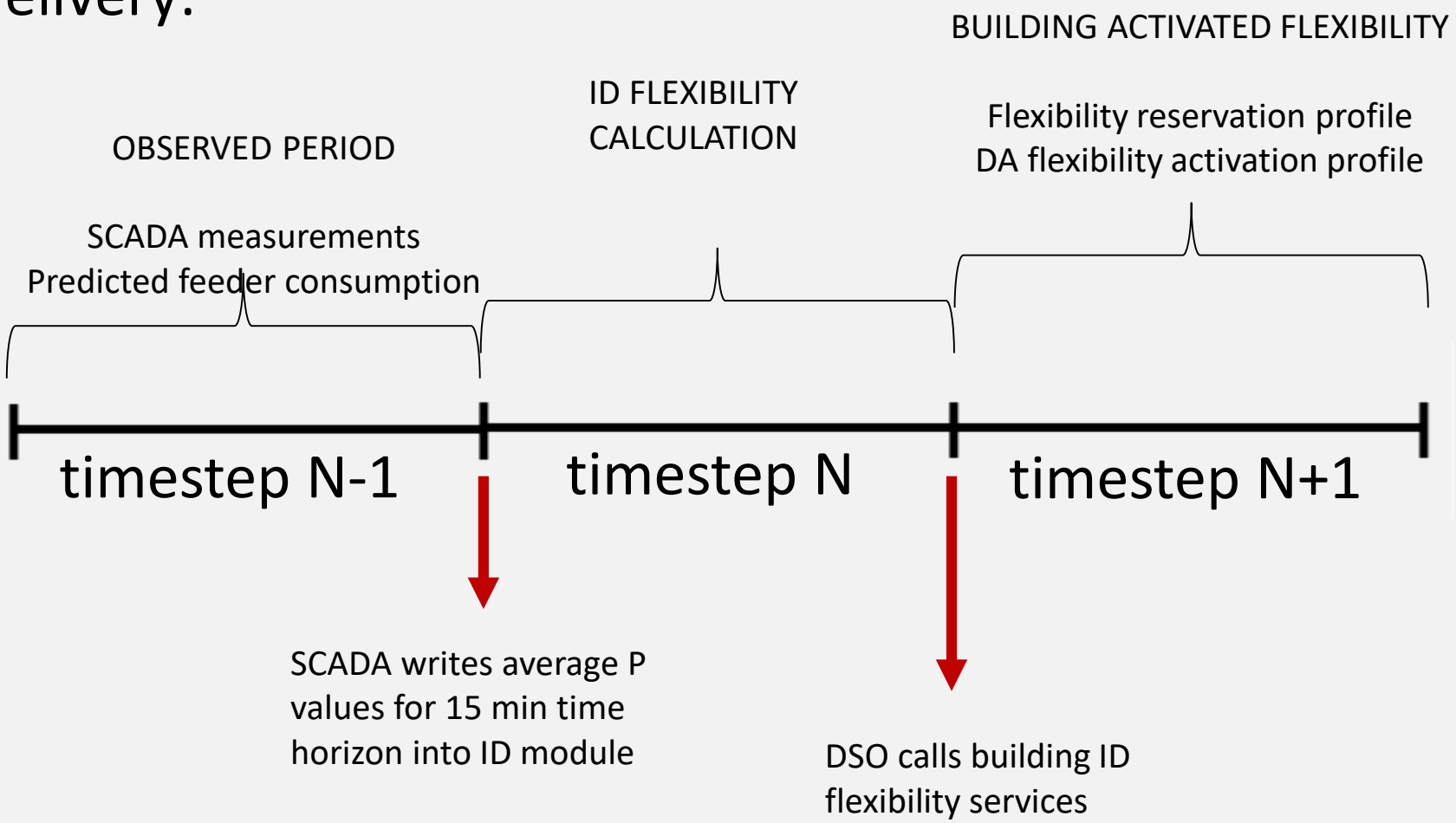
Short-term Intra-day Module (Online)

- Intra-day operations allow DSO to improve day-ahead schedule with real time measurements and prices
  - ST ID module is interconnected with the long-term contract, ST DA module and with SCADA measurements
- Focus: triggering flexibility through real-time measurements in case DA forecasts deviate from actual events

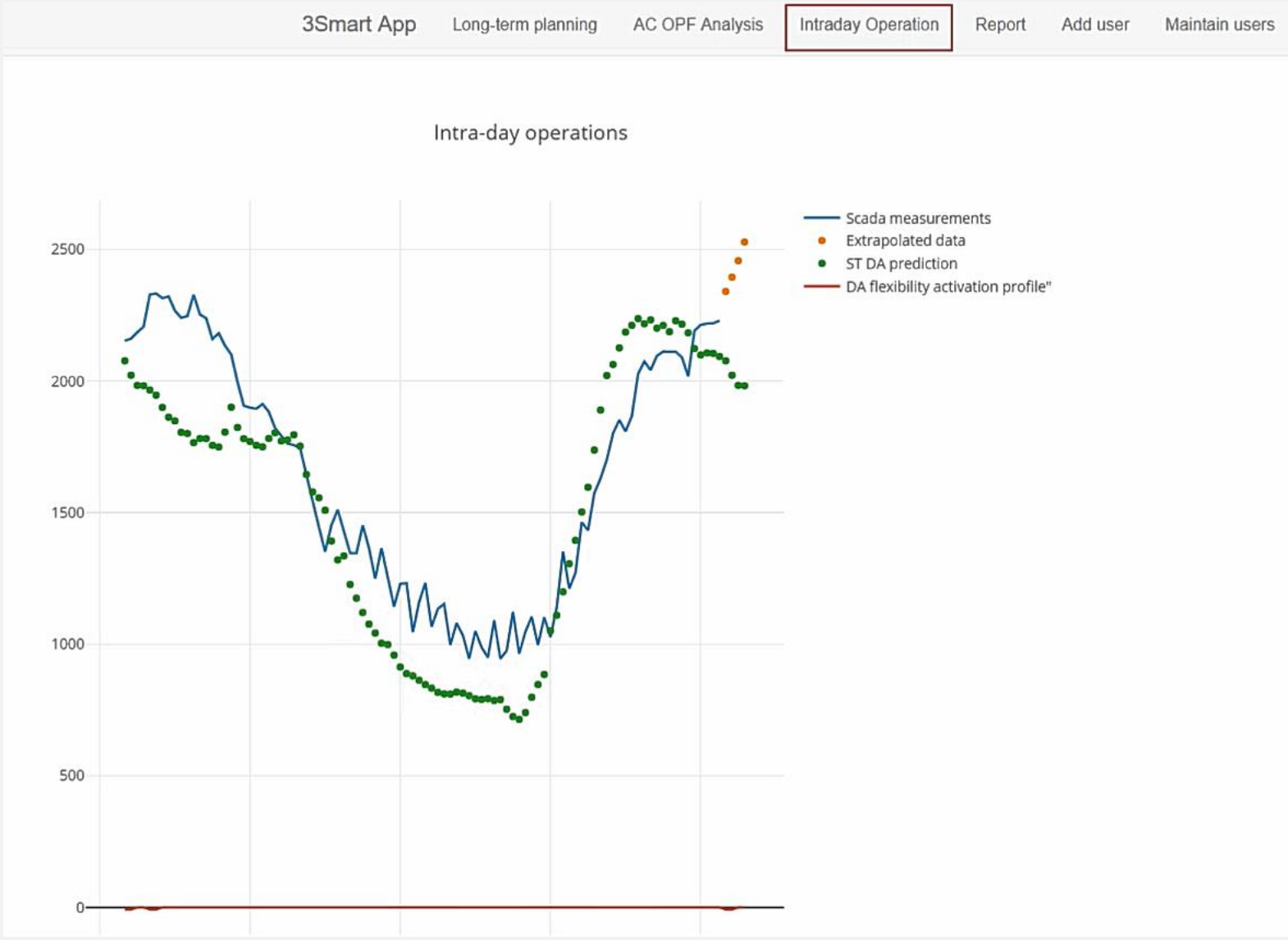
- ID flexibility is triggered only in case of imbalances (if the measured value is higher than the triggering value):
  - If such event occurs before the scheduled utilization of the flexibility coming from the day-ahead module
  - In case of unforcasted events or „specific” network conditions.

Short-term Intra-day Module Coordination

Day of delivery:



3Smart Platform – Intra-day Module



Conclusion

- Open source tools for integrated operation and planning of flexible buildings and distribution network supports two way communication between DSO and flexibility service providers
- Running long-term calculations, operators calculate needed flexibility and define reservation and activation prices and penalties
- By day-ahead operations, operators determine building flexibility potential as the distribution network/system operator asset, and by intra-day operations improve day-ahead schedule with

Acknowledgments

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FER

FUTURE

IRES-8

中欧关系 1975 - 2015 EU-CHINA RELATIONS