European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	ROCOF
Title	Real-time Price-based Energy Management Strategies of Commercial building
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TA Call No.	**2**

HOST RESEARCH INFRASTRUCTURE			
Name	**National Smart Grid Laboratory (NSGL), SINTEF Energy Research - Trondheim, Norway**		
Country	**Trondheim, Norway**		
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1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

Motivation

Algorithms for the Energy Management System realization in commercial/industrial buildings and households are becoming more popular due to increasing of smart hardware and software based plug-in/ready solutions. New buildings are using HVAC (Heating, Ventilation and Air Conditioning) systems for energy efficiency and smart control of building eco-system. Energy efficiency as passive saving is used almost everywhere. Household and flat EMS is basically used for entertainment system and lighting control, however energy saving projects are still not massively used in the commercial sector.
For the commercial and office type buildings exclusive HVAC the EMS is used for smart control of building devices to increase the comfort level of inhabitants. The potential of Demand Response programs under EMS should be estimated.

Objectives:

This project proposes to achieve the following objectives.

1. Overwiev the shiftable load saving potential for the commercial building under different test case scenarios.
2. Overwiev the add-ons potential for the commercial building under different test case scenarios.
3. Test the possibility to run developed models under RT conditions, that will be usefull for future tasks.

Methodology & Approach

To overview different test case scenarios for the Energy Management System authors define the possible Energy Management Strategies with three criteria. The reaction time of provided EMS: real time with parameters that could be measured only inside in the object, real time with parameters that could be achieved outside from the object (example: weather conditions) and forecasting system when the each used parameter for EMS control could be forecasted to increase the efficiency of the system. The second criteria for EMS is equipment that is used for the object: consumer, prosumer, add-ons (storage, electrical vehicles, PV). The last criteria defines in which part of DR program this EMS is involved: price-based, incentive-based or hybrid program. The profit from the EMS should be regulated by prosumer by increasing or decreasing his comfort level.

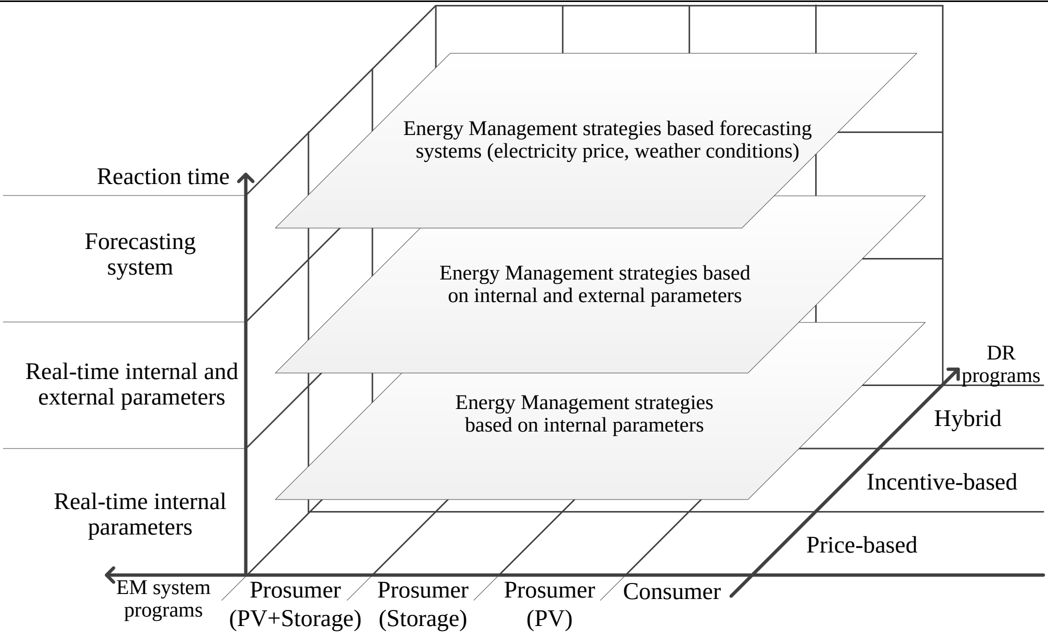

Fig. 1. Energy Management strategy architecture

For the flexible load control was divided into three types with different behavior, load amount and control algorithms.

- Type 1: Boilers that are installed in commercial building and could shift their load up to one hour ahead;
- Type 2: flexible shiftable load that could be used for shifting up to three hour ahead horizon;
- Type 3: flexible low level load that behavior is known and could be shifted up for the each hour in the working hours.

The shiftable load amount was taken as assumption from devices installed in the lab of ROCOF group.
Test cases information:

- 2 test cases with low prices in LV* zone for the prosumer type EMS
- 2 test cases with high prices in LV zone for the prosumer type EMS
- 2 test cases with low prices in LV zone for the prosumer type EMS with storage system
- 2 test cases with high prices in LV zone for the prosumer type EMS with storage system

**Latvia is involved in NordPool electricity power market, where prices are formed for different zones bases on market conditions*

Set-up

An experiments setup using OPAL-RT system during all test cases was implemented in the pure simulation mode. The model was completed with energy flow control, without voltage and current parameters. The data what was used during the simulation is following: total building load behavior (historical data), three flexible load types behavior (from IPE lab consumption analysis) and price data (historical data from NordPool LV zone). All parameters are used with 1s step resolution inside in OPAL system, after each timestamp all parameters are updated – new data is taken by uploading this information from Matlab file (respectively historical data about load/price behavior).

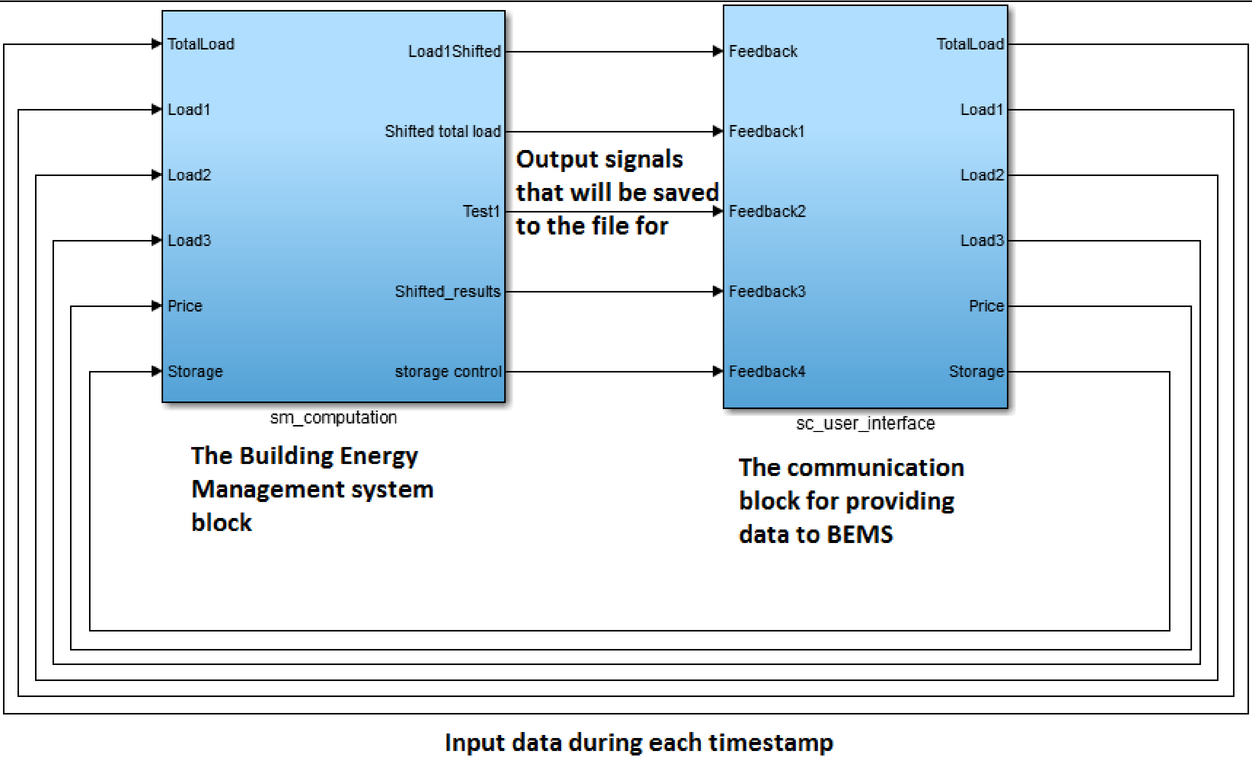

Fig. 2. Model of EMS compiled in OPAL

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

Results

During the experiment flexible load amount (load that is possible to shift) in average per case is: 11.55%, 22.82%, 16.22% and 21.19 % of total load of building consumption for each week of test respectively. The load what was used (shifted) during this period is: 1.96%, 3.13%, 2.12% and 2,51% respectively of total load. In the figure 3 the total load behavior, total load after shifting, shifted loads, price and total load with storage are presented. All cases are shown in this figure. The two first weeks that is 18.02.2017-25.02.2017 and 29.04.2017-06.05.2017 are representing the low price level with smooth changes the next two weeks 10.06.2017-17.06.2017 and 12.08.2017-19.07.2017 represent high price variation in LV zone.

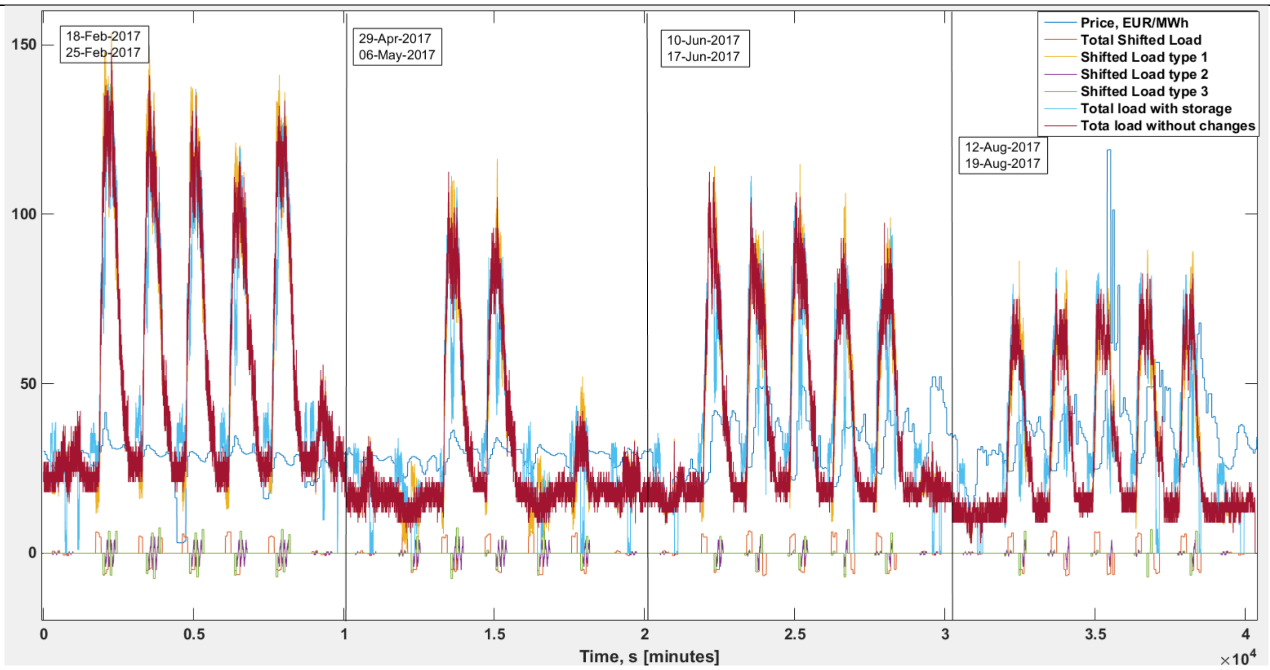

Fig. 3. Test case results

The income from the different test case are presented in table 1.

Table 1

Test case impact on savings for prosumer

Test case / Consumption type	Week 1	Week 2	Week 3	Week 4	TOTAL
Regular	**250.42**	**130.43**	**213.03**	**191.22**	**785.1**
With flexible loads	**249.43**	**129.73**	**211.04**	**187.58**	**777.77**
Profit	**0.99**	**0.70**	**1.99**	**3.64**	**7.33**
Flexible & storage **(50 kWh)**	246.10	128.19	205.89	179.23	759.41
Savings in storage	0.27	0.29	0.64	0.97	2.17
End cost	**245.83**	**127.89**	**205.25**	**178.26**	**757.24**
Profit	**4.59**	**2.54**	**7.78**	**12.96**	**27.86**
	All profit and cost in EUR				

Conclusion

Flexible load used in scope of commercial building even with high price peaks could be useful only if the amount of flexible load is high in comparison with total load at this moment. In the situation when the possibilities to shift the load is very low it is better to focus on the load decreasing that is more easier from technical realization and could provide more impact. Load shifting for the commercial type building could provide more gain if there is high manufacture type load that could move their behavior even one hour more ahead. On the other hand, the observed flexible load of ROCOF group was chosen to do not interrupt working process of inhabitants. It is possible to increase the flexible load by decreasing the comfort level of workers. However, the full building device consumption behavior was not completed jet and flexible load amount could be increased in the practical realization of EMS.

Lessons learned

During the ROCOF group stay period in SINTEF lab the RTS operation process and coding of Simulink to run the RTS was learned. The deeper knowledge of OPAL system can be used in future project and task where the RTS could be used.
Real time control of EMS during ROCOF group test allow to focus on EM strategies review process to provide more complicated and comprehensive EM strategy architecture.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

Planned to publish in national conference RTUCON (in SCOPUS / IEEE database).
Results will be used for future practical implementation of EMS in commercial building (pilot).
Results and gained experience will be used for CloudGrid project development (will be helpful to review EM strategies structure).