5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019

Co-simulation tool for hybrid energy system optimisation

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Background

Intergovernmental Panel on Climate Change (IPCC), estimates the human induced global warming between 0.8°C and 1.2°C

Allen, M.R., O.P. Dube, W. Solecki, F. Aragón-Durand, W. Cramer, S. Humphreys, M. Kainuma, J. Kala, N. Mahowald, Y. Mulugetta, R. Perez, M. Wairiu, and K. Z. (2018)

Some consequences…

- 2/3 of the population could be affected by weather related disaster.
- Up to 16% of the Mediterranean climate region may become arid.
- Annual damage due to flooding could rise from €5billion/year to €112billion/year.

(European Commission, 2018a).

Actions

November 28th 2018 the European Commission presented a long term strategic vision for a competitive carbon neutral economy by 2050 (“2050 long-term strategy”).

Committed to a net zero target by 2050 as recommended by The Committee on Climate Change (CCC) in his report “Net Zero - The UK's contribution to stopping global warming”

Actions

Impact of the building sector:

- 40% energy demand EU.
- 32% energy demand world.
- 26% (considering direct and indirect) GHG emissions in the UK.

(Sajn 2016; Mauro *et al.*, 2015; Committee on Climate Change, 2019a)

Due to the low replacement rate refurbishing existing buildings is a necessary path for the reduction of GHG and the Committee on Climate Change indicates the main interventions:

- Efficiency improvement (in terms of reduced energy demand).
- Low-carbon heating systems.

One of the options to reach the net-zero target is:

- FULL ELECTRIFICATION OF THE HEATING COMPARTMENT

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Case study

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Case study

Decentralized, full electric, heating system will serve 39 homes in total

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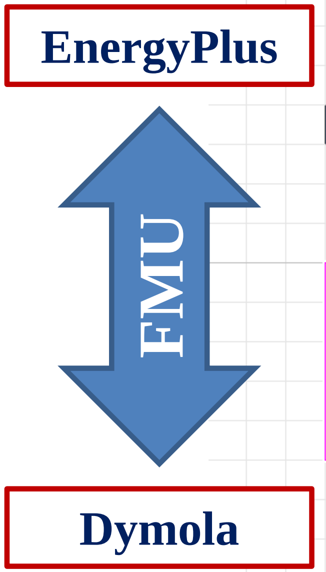
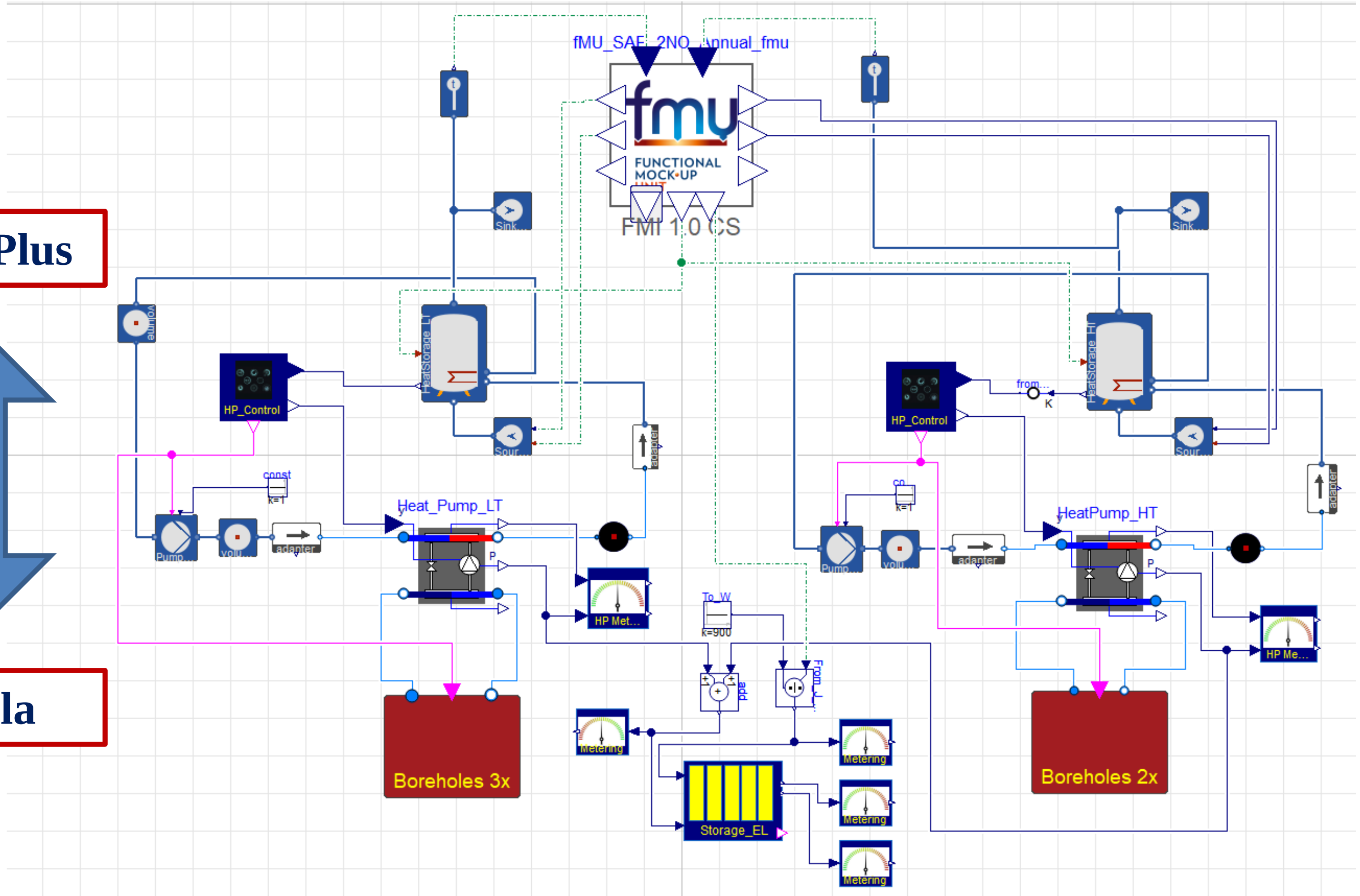
Co-Simulation Model





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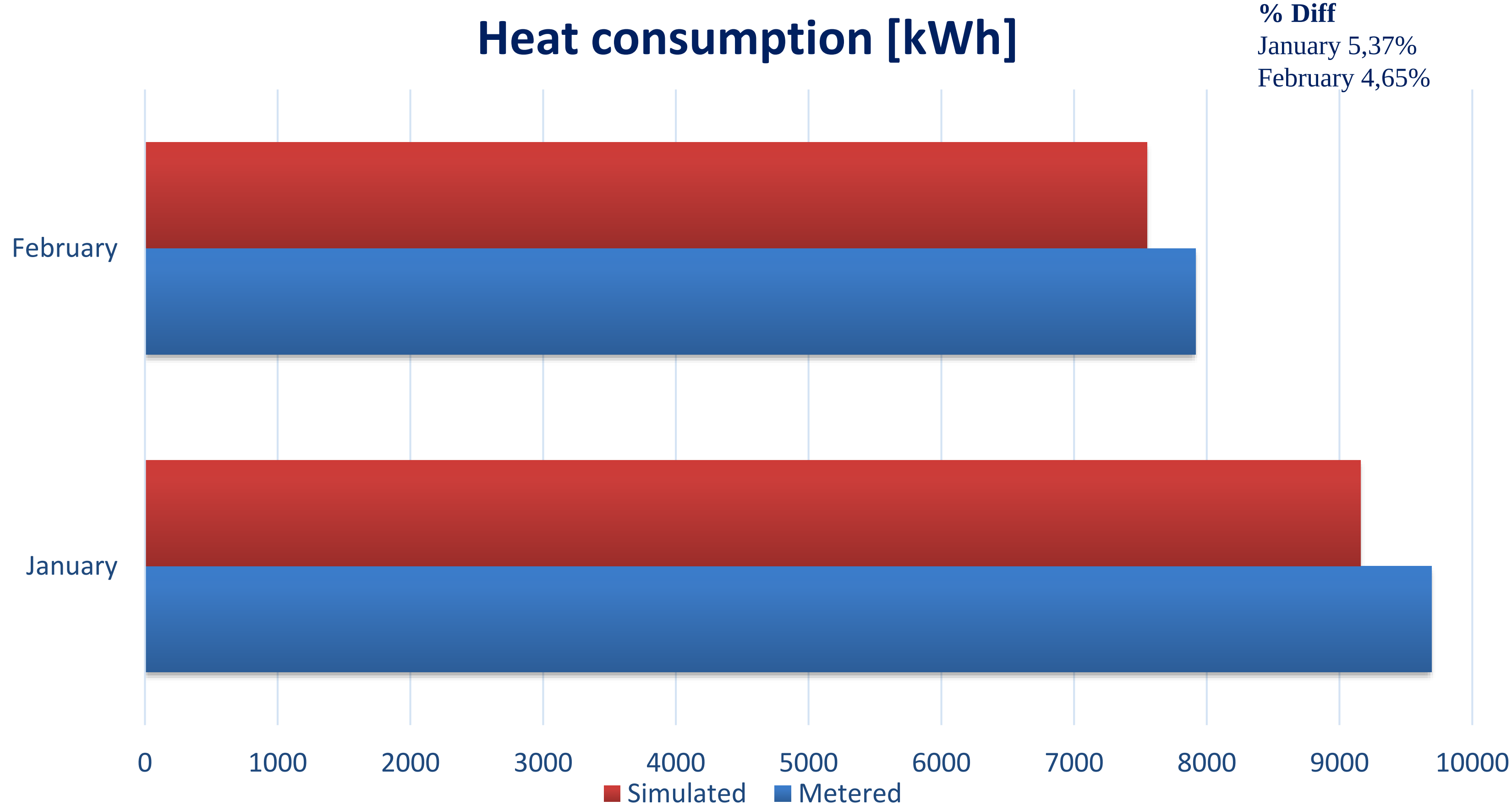
Validation

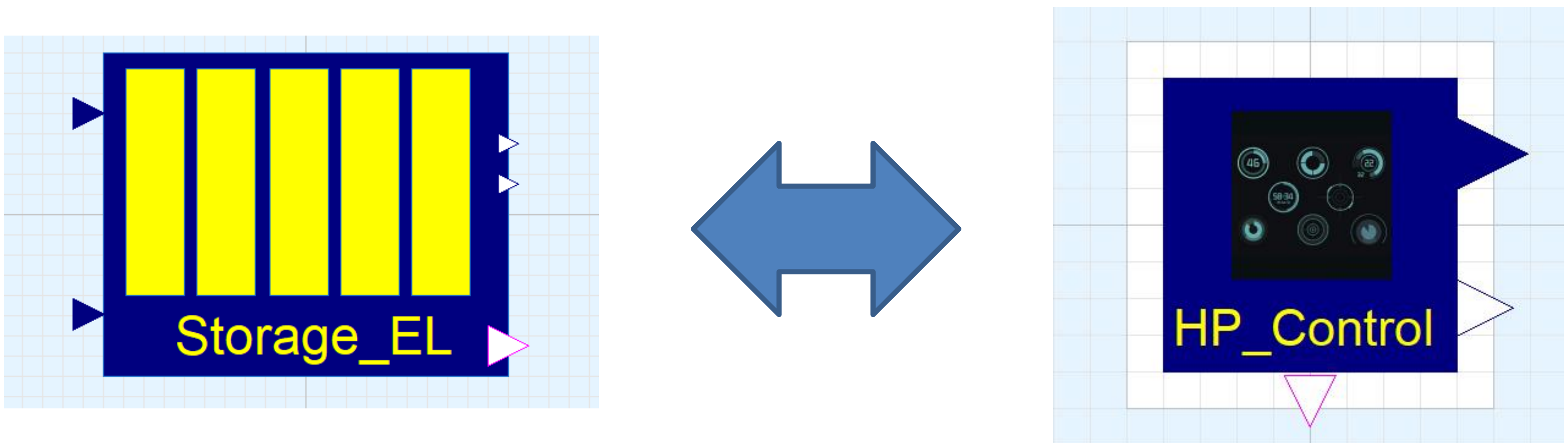
% Diff
January 5,37%
February 4,65%



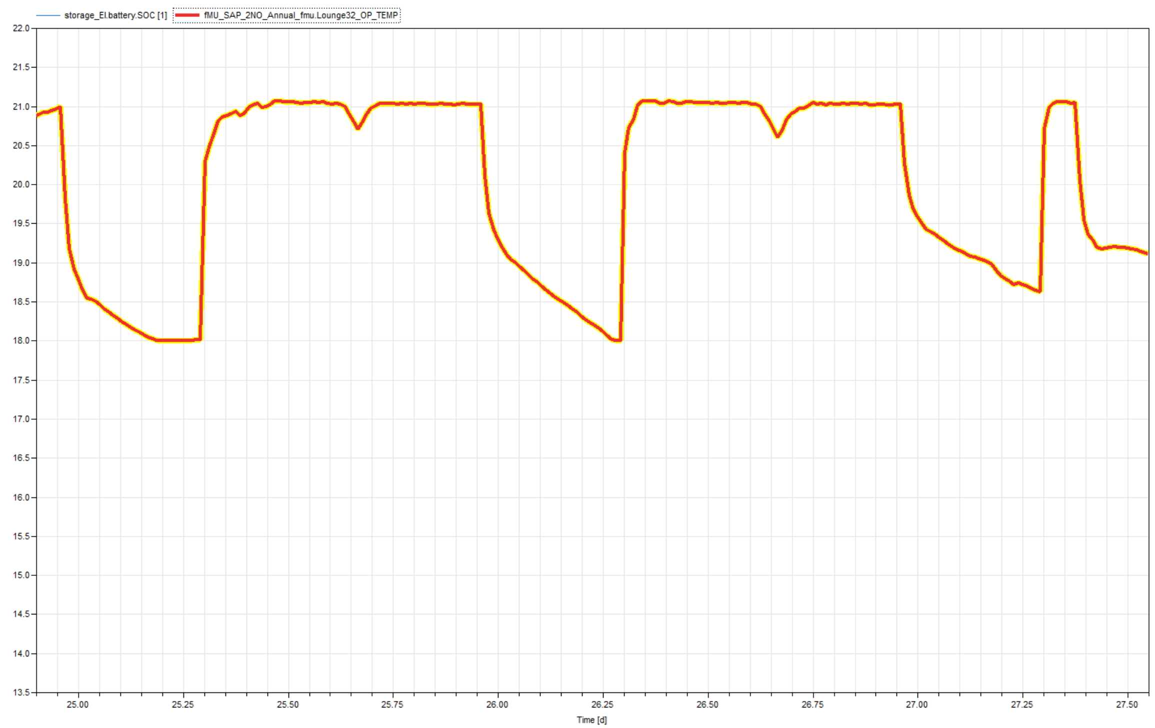
Control

Avoid the high electricity price in the afternoon

- Use all the photovoltaic production in the heat pumps
- Store the eventual surplus in the battery
- Switch off the heat pumps in the hours in which the electricity is more expensive storing the PV production in those hours
- Use the stored energy to run the heat pumps after 4pm

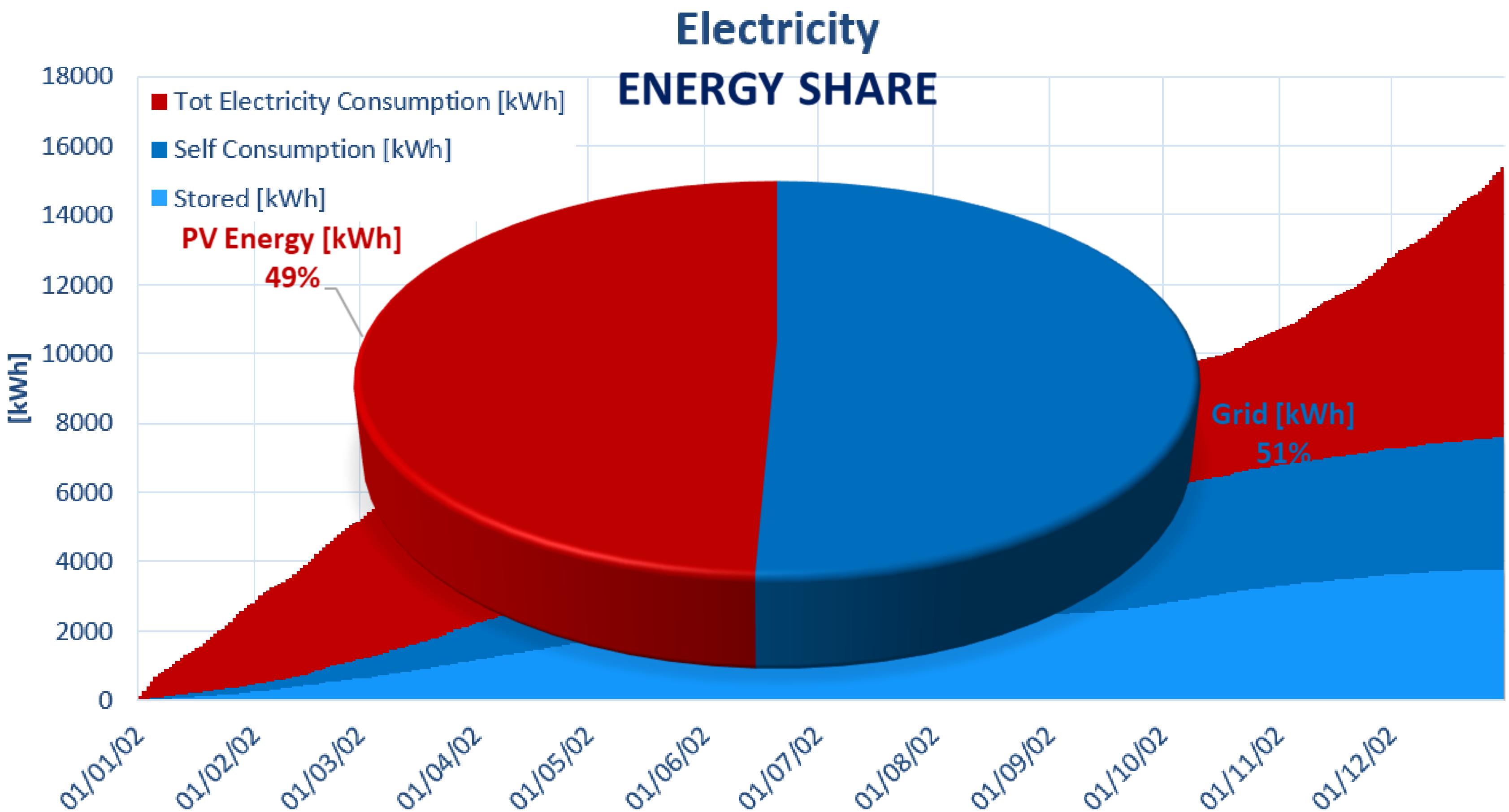


Control



Thanks to the thermal storage and to the thermal inertia of the buildings even with the HP off the room temperature stays basically constant with a fluctuation of ~0.4°C

Results


Electricity
ENERGY SHARE
Tot Electricity Consumption [kWh]
Self Consumption [kWh]
Stored [kWh]
PV Energy [kWh]
49%
Grid [kWh]
51%
[kWh]
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
01/01/02
01/02/02
01/03/02
01/04/02
01/05/02
01/06/02
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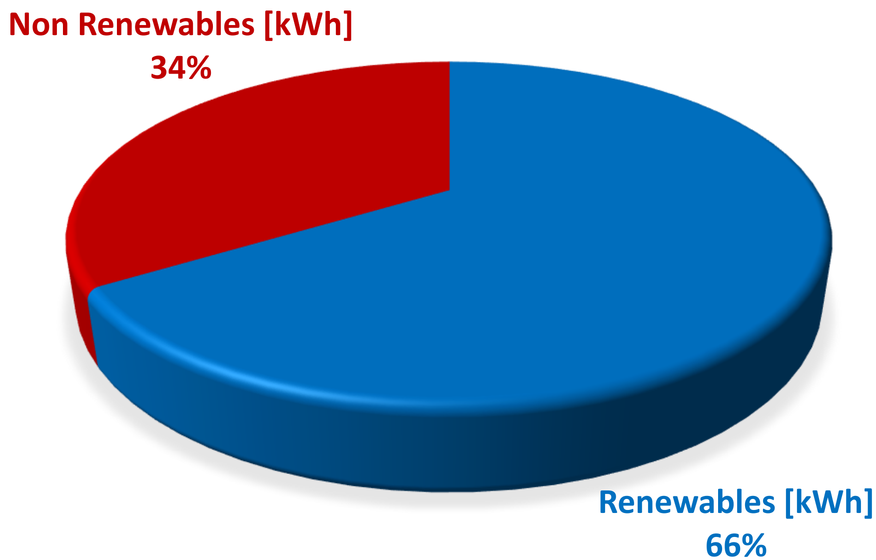
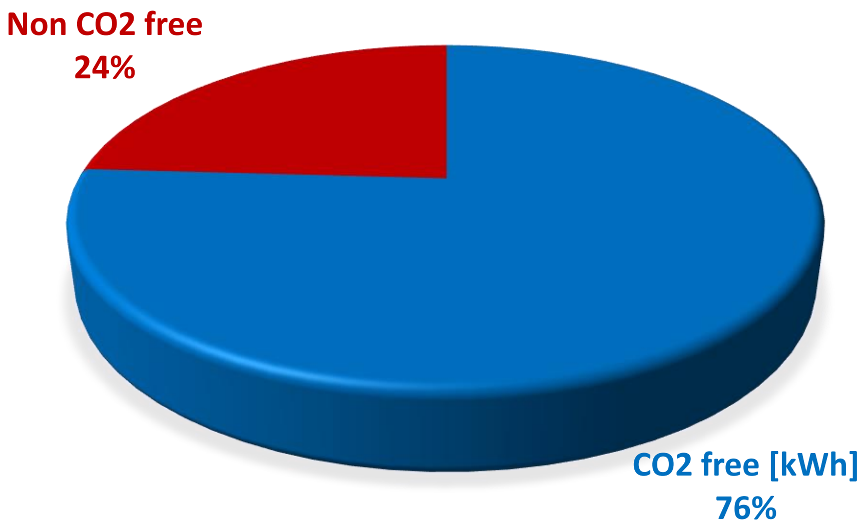
01/10/02
01/11/02
01/12/02

Results

RENEWABLES SHARE



CO_2 FREE ENERGY



Energy Mix UK 2018 (Source:DUKES 2019)			
Gas	39.5%	Coal	5.1%
Renewables	33.0%	Other fuels	2.9%
Nuclear	19.5%		

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Conclusions

- The co-simulation of this energy cluster gives the opportunity to study the system in a very precise and accurate way
- Dymola in particular allows us to simulate all the dynamics of the energy centre with a detailed view of the energy flows through all the branches of the system.
- Dymola offers also the opportunity to create and manage the control strategies of the entire system, this is vital from the point of view of optimization
- The simulation shows that the PV system is capable to provide almost 50% of the electricity needed by the heating system, furthermore taking into account the UK's energy mix the share of renewable energy goes up to 66% and 76% of the electricity is carbon-free.

Future steps

- Optimization of the control strategy to find the optimum in between energy efficiency and cost of electricity.
- Investigation of a seasonal heat storage in the boreholes, using the excess of PV production during the summer.
- Optimization of the battery size, looking at the balance between storage cost and energy savings.

Thank you for your attention, any question?

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