Test protocol

TSRT10, Project Group 7

December 18, 2022

Version 1

Status

Reviewed	Jan Åslund, Daniel Jung	2022-12-08
Approved	Jan Åslund, Daniel Jung	2022-12-08

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DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
1	2022-12-07	First version	AB	PK

1 INTRODUCTION

In this document the test protocol for the project is presented. The test ptotocol includes the tests that have been performed in order to ensure that all requirements, defined in the Requirement Specification, is fulfilled.

The tests are carried out in accordance with the Test plan. The tests are presented according to 1.

Table 1: *Test template*

Test number:	-
Goal:	-
Requirement number:	-
Test description:	-
Responsible person:	-
Deadline (week):	-
Criteria:	-
Test protocol:	-
Result:	-
Comment:	-
Approved by:	-

1.1 Test status

The conducted tests will receive a grade of *Passed* or *Failed*. It is possible that the tested task is completed but not in a satisfactory way which needs to be adjusted for. The test can therefore receive a grade of *Passed with complementary work*. If the performed task can not be accomplished within the given trials, a *Failed* grade will be set. If a failed grade is set for some test, the test needs to be redone completely after revision. If the grade *Passed with complementary work* is given, a general description of the problem will be made in the test protocol. This can subsequently be discussed with project orderer whether it needs to be revised or not.

1.2 Failed test

In the event of a failed test, various measures must be applied to ensure that the specified requirement is fulfilled. It may be appropriate to either redo the test or to renegotiate specific requirement with the costumer and have a new test done if the discovered problem will not be able to be solved within the specified time horizon.

1.3 Requirements without testing

Some of the requirements in the requirements specification can be verified without a detailed testing. Table 2 shows the requirements that are considered too trivial for a detailed test plan.

Table 2: *Requirements without testing*

Requirement number	Type	Description
1, 2, 21	General	Comparisons and evaluations
5	Interface	Monitoring
11	Design	Dimensional analysis
14, 17, 26	Functional	Sensitivity analysis, comparisons and investigations
31	Development	Discussion
32, 33	Reliability	Collection of data and general assumptions
34	Economy	Total time spent on project

1.4 Testing responsibilities

The group's test manager has overall responsibility for the tests. The execution of the tests and subsequent analysis of test protocols will be divided among the team members. Modification of test must be brought to the attention of the group before realization and execution.

1.5 Test structure

A general description of the test protocol layout is shown below. In addition to the test results, a list describing problems with tests rated as *Passed with complementary work* will also be presented.

Table 3: *A template showing the structure of how the rests will be summarised.*

Test no.	Requirement Tested	Date	Test Responsible	Status
1	Req. no tested	Date of exe.	Responsible project member(s)	Test Grade
2	...	...	...	...

2 TESTS

In this section the planned tests are presented. Only requirements with priority **Base** are specified. The structure will be as follows:

- Interface requirement tests
- Design requirement tests
- Functional requirement tests
- Performance requirement tests

2.1 Tests of interface requirements

In this section interface tests are presented.

Test No.	Req No.	Date	Description	Test Resp.	Grade
1	4	44	Multiple scenarios with different activities related to the electricity consumption of the single house should be selected and the simulation should be run to evaluate the adjustment possibility.	AB	Passed

Table 4: *Test 1 - Electricity consumtion*

Test number:	1
Goal:	Test if program can run with adjustable activities related to the electricity consumption
Requirement number:	4
Test description:	Evaluate adjustment possibilities for electric consumption
Responsible person:	AB
Deadline (week):	44
Criteria:	It should be possible to run the program with stationary battery or EV and to be able to select if PV production is used or not
Result:	Passed
Comment:	It is possible to choose between stationary battery and EV and to turn PV on/off. Changes in electric consumption from grid reflects demand of EV and production of PV.
Approved by:	PK

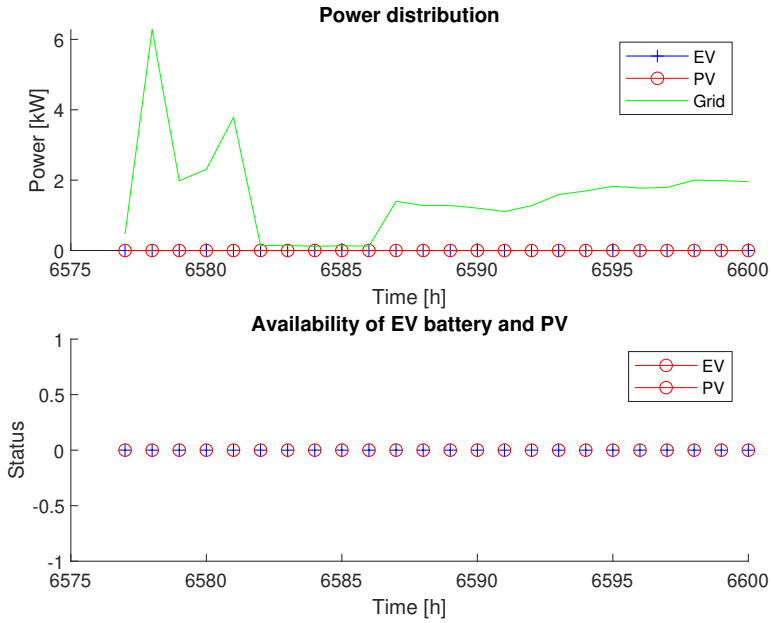

Figure 1: Power distribution with no EV and PV

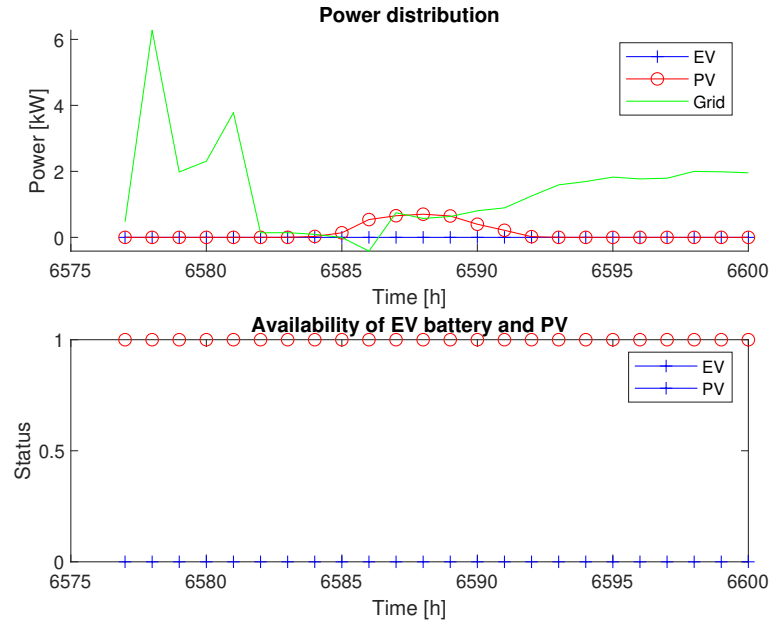

Figure 2: Power distribution with PV but no EV

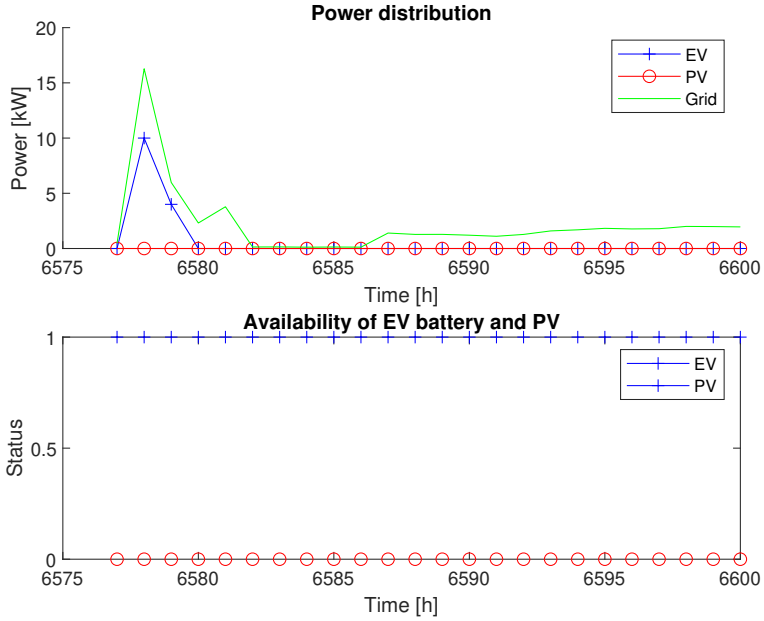

Figure 3: Power distribution with EV but no PV

2.2 Tests of design requirements

In this section design tests are presented.

Test No.	Req No.	Date	Description	Test Resp.	Grade
2	8	43	The accumulator tank with heat pump model should be simulated and investigated individually. The model should also be tested as part of the low-voltage grid.	AB	Passed
3	9	43	The stationary battery model should be simulated and investigated.	TN	Passed
4	10	43	The thermodynamic house model should be simulated and investigated.	AB	Passed
5	12	43	The water usage in household model should be simulated and investigated individually. The model should also be tested as part of the low-voltage grid.	AB	Passed
6	13	43	The PV production model should be simulated and investigated individually. The model should also be tested as part of the low-voltage grid.	TN	Passed

Table 5: *Test 2 - Accumulator tank model with simplified heat pump*

Test number:	2
Goal:	Test accumulator tank model with simplified heat pump
Requirement number:	8
Test description:	Different time intervals from one day to one month should be simulated with added power or water usage to evaluate model functionality
Responsible person:	AB
Deadline (week):	43
Criteria:	The model should variate tank temperature and have loses accredited to it. Heat pump should work with specific COP value.
Result:	Passed
Comment:	Tank temperature depends on input power and water usage as it should. No power loses were tested.
Approved by:	TN

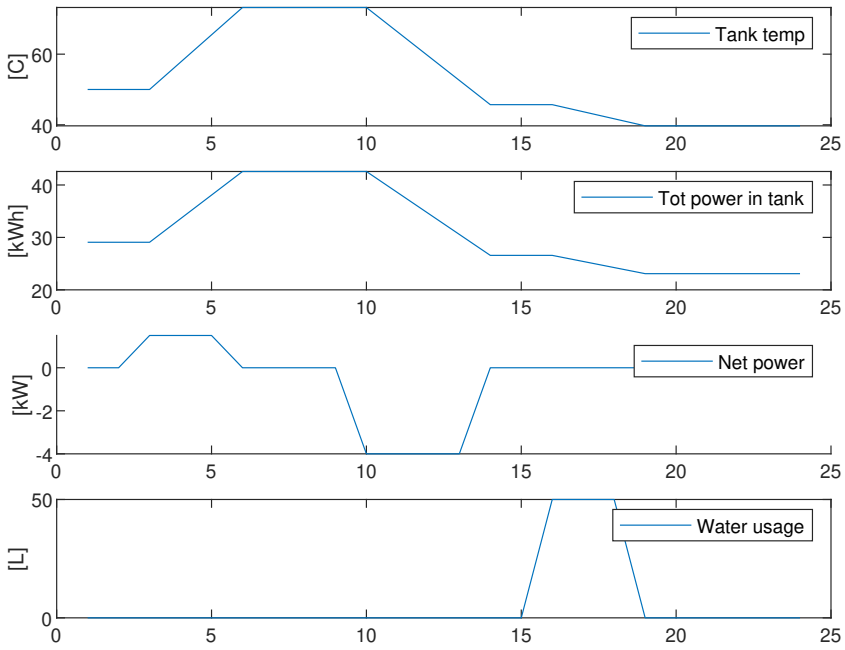

Figure 4: Test 2: Figure showing variation of the tank temperature and total energy stored in the tank due to net power and water usage.

Table 6: *Test 3 - Stationary battery model*

Test number:	3
Goal:	Test stationary battery model
Requirement number:	9
Test description:	Test different capacities, charging and discharging limits
Responsible person:	TN
Deadline (week):	43
Criteria:	Battery should not charge over 90 % and discharge below 10 % total capacity. Battery charging/discharging per hour should stay under the defined limits
Result:	Passed
Comment:	Battery capacity can be altered and charging and discharging limits work as well.
Approved by:	AB

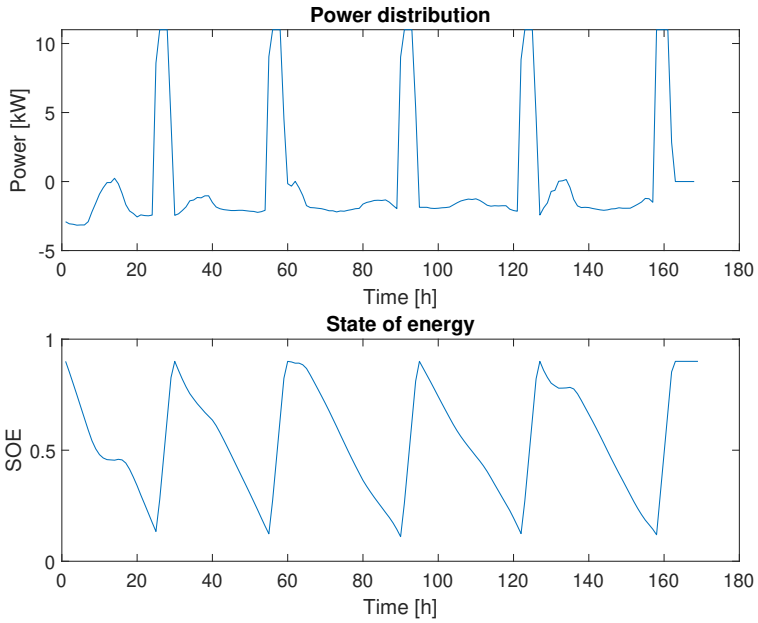

Figure 5: Results from the Stationary Battery model with limits for SOE at 10% to 90%

Table 7: *Test 4 - Thermodynamic house model*

Test number:	4
Goal:	Test the thermodynamic house model
Requirement number:	10
Test description:	Simulated with and without added power to evaluate model functionality for house model
Responsible person:	AB
Deadline (week):	43
Criteria:	Model should respond to outdoor temperature variations and added power
Result:	Passed
Comment:	Inside temperature varies with outside temperature, sun radiation and added power.
Approved by:	PK

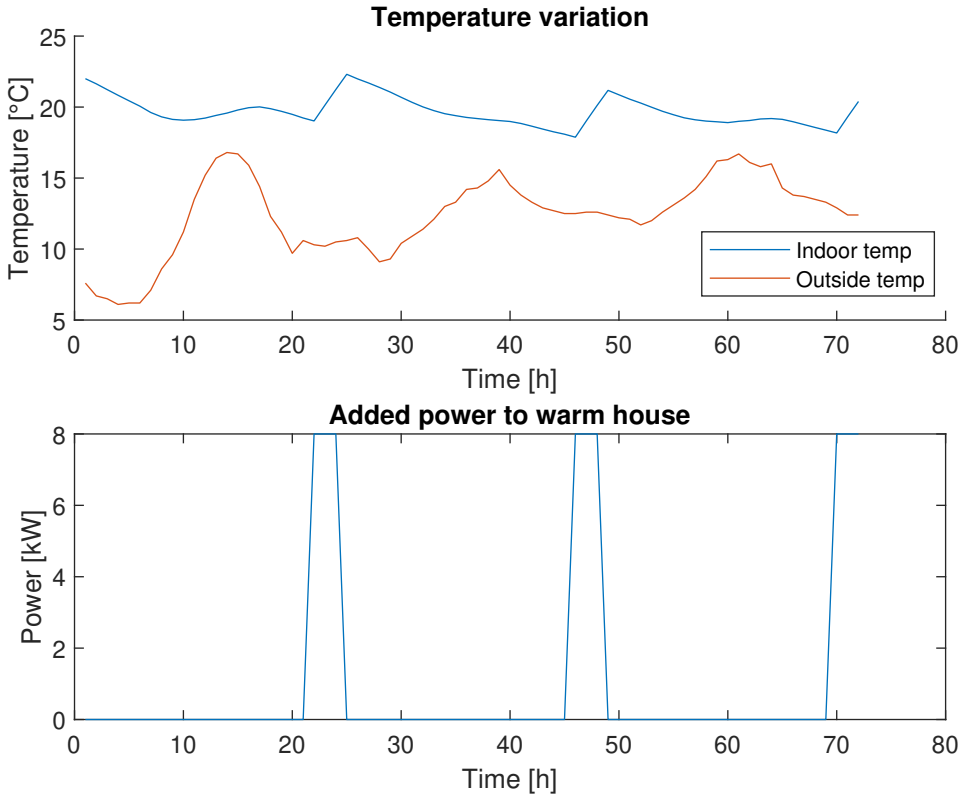

Figure 6: Results from the thermodynamic house model

Table 8: *Test 5 - Accumulator tank model and simplified water usage*

Test number:	5
Goal:	Test accumulator tank and its compatibility with simplified water usage
Requirement number:	12
Test description:	Test model functionality with water usage.
Responsible person:	AB
Deadline (week):	43
Criteria:	Model must take in representative water usage values for every hour independently of test interval
Result:	Passed
Comment:	Accumulator tank responds to water usage. Both temperature and total power in the tank depends on the water usage as expected.
Approved by:	PK

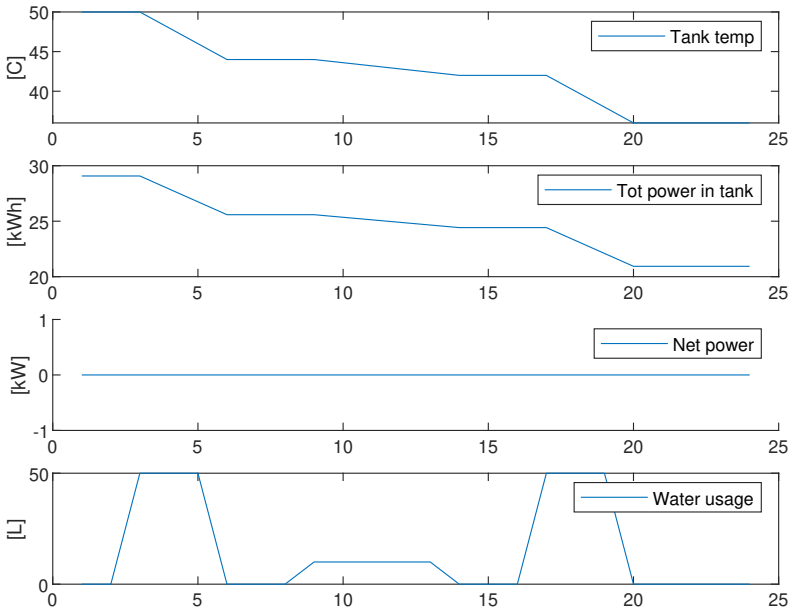

Figure 7: Accumulator tank temperature and total power variation with water usage

Table 9: *Test 6 - EV battery model*

Test number:	6
Goal:	Test PV production model
Requirement number:	13
Test description:	Test different periods from one year data of solar radiation.
Responsible person:	TN
Deadline (week):	44
Criteria:	The model should take into account sun radiation and calculate the power production per standard solar module
Result:	Passed
Comment:	The PV model can load solar radiation data file and calculate power production per module
Approved by:	PK

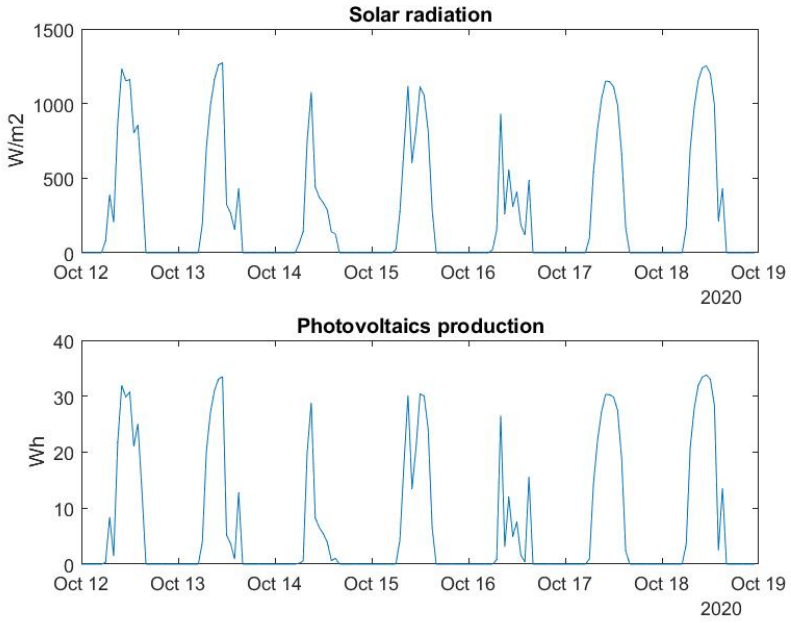

Figure 8: Simulation of PV production model

2.3 Tests of functional requirements

In this section functional tests are presented.

Test No.	Req No.	Date	Description	Test Resp.	Grade
7	15	43	The real time optimization should be run individually for an electrical vehicle battery model and multiple, both simple and more complex, cases should be tested to evaluate the quality of the optimization algorithm.	TN	Passed
8	16	45	The real time optimization should be run individually for a hot water accumulation tank and heat pump. Multiple, both simple and more complex, cases should be tested to evaluate the quality of the optimization algorithm.	AB	Passed
9	25	46	A test, where single house data should be run first to evaluate the detection of acceptable voltage range, preferably in figure form. Secondly, the full scale test of the code should be run to investigate the detection of acceptable voltage range in the low-voltage grid simulation.	AB	Passed

Table 10: *Test 7 - Test MPC for EV battery*

Test number:	7
Goal:	Test MPC for EV battery
Requirement number:	15
Test description:	The real time optimization should be run individually for an electrical vehicle battery model and multiple cases, both simple and more complex, should be tested to evaluate the quality of the optimization algorithm.
Responsible person:	TN
Deadline (week):	47
Criteria:	The EV battery should be charged when available and when the price is low
Result:	Passed
Comment:	From Figure 9 we can see that the EV Battery is charged when the spot price is at its lowest
Approved by:	AB

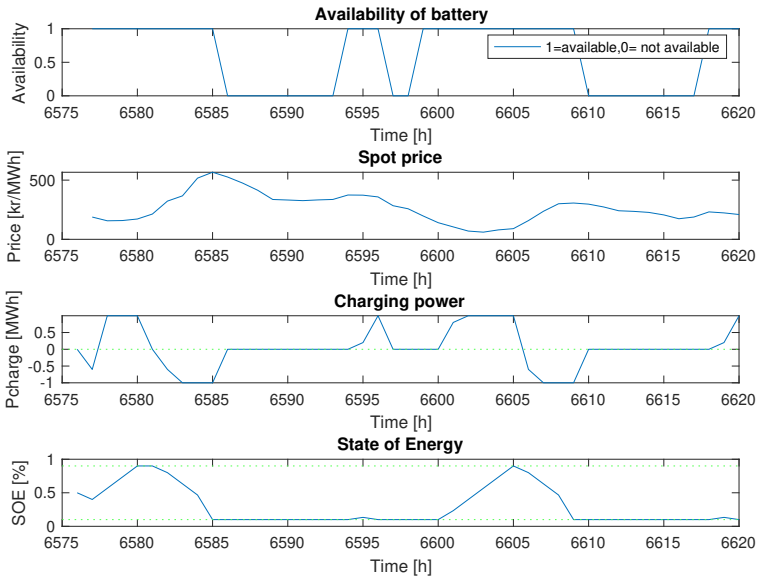

Figure 9: Simulation for the model with MPC control for the EV battery

Table 11: *Test 8 - Test MPC for accumulator tank*

Test number:	8
Goal:	Test MPC for accumulator tank
Requirement number:	16
Test description:	Run test with different water usage patterns to test MPC controller for accumulator tank with no EV or PV
Responsible person:	AB
Deadline (week):	45
Criteria:	The controller should retain water temperature inside set limits while water is used and buy electricity to heat water when price is cheapest on known horizon.
Result:	Passed
Comment:	Controller takes in predicted electricity consumption, water usage and weather parameters to controls water temperature inside the set limits while charging with cheapest price.
Approved by:	PK

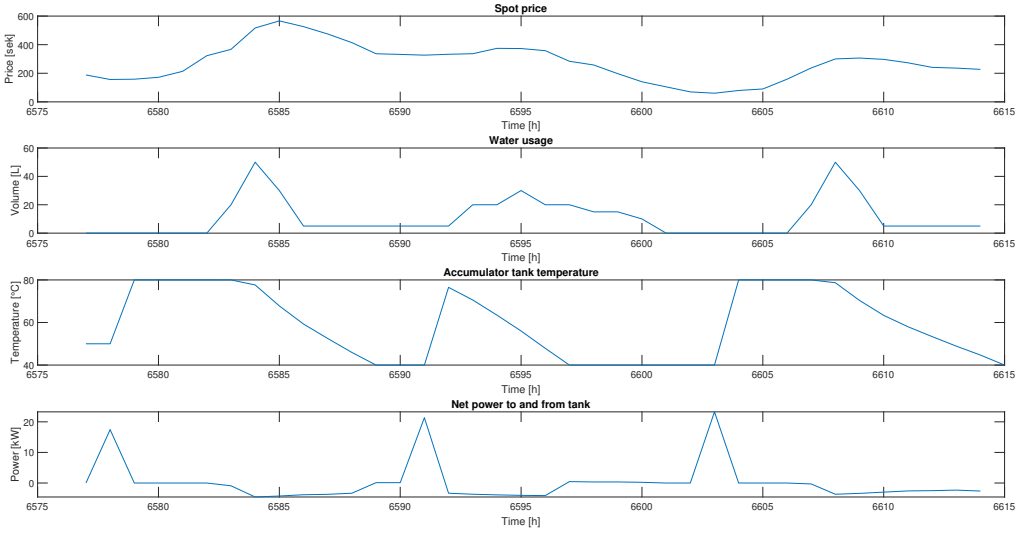

Figure 10: Accumulator tank water temperature control with MPC

Table 12: *Test 9 - Single house hold and low voltage grid*

Test number:	9
Goal:	Test single house hold and the whole grid
Requirement number:	25
Test description:	First, run simulation for a single house hold with different voltage limits. Secondly, run simulation for the whole grid with different voltage limits
Responsible person:	AB
Deadline (week):	46
Criteria:	The defined voltage range should be indicated and detected by the program
Result:	Passed
Comment:	The program can detect and indicate when voltage is outside the set limits, see figure 11 and figure 12
Approved by:	PK

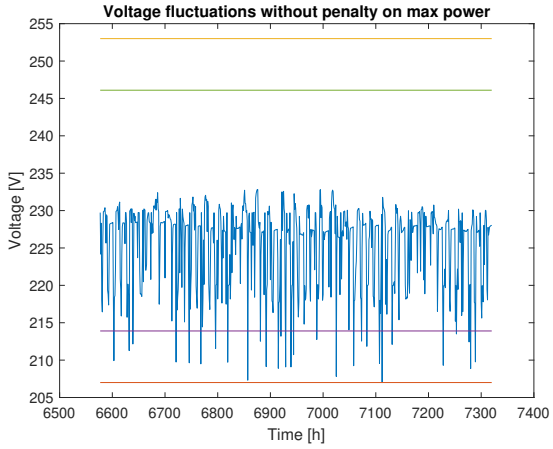

Figure 11: Voltage fluctuations for a single house hold and voltage limit indicators of 7 % and 10 % from nominal 230 V

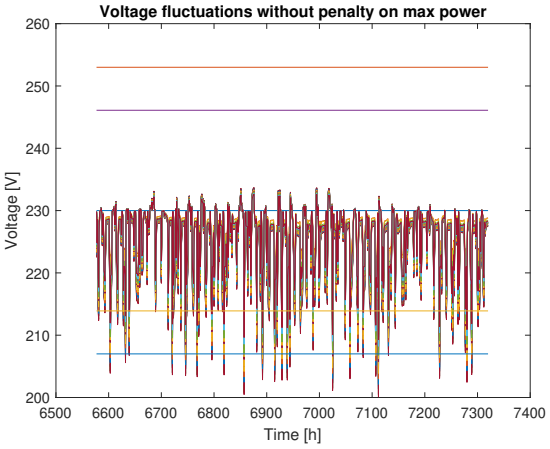

Figure 12: Voltage fluctuations for the whole grid and voltage limit indicators of 7 % and 10 % from nominal 230 V

2.4 Tests of performance requirements

In this section performance tests are presented.

Test No.	Req No.	Date	Description	Test Resp.	Grade
10	28	44	Test where algorithm takes in different data files provided by Tekniska Verken should be done and evaluated.	AB	Passed with complementary work
11	29	46	Multiple historic data files of energy consumption, both simple and more complex, should be simulated to test and evaluate the quality of the prediction algorithm.	AB	Passed

Table 13: *Test 10 - Data*

Test number:	10
Goal:	Test that program can take in different data files provided by Tekniska Verken
Requirement number:	28
Test description:	Load different data files from Tekniska Verken and run the program
Responsible person:	AB
Deadline (week):	44
Criteria:	The program should be able to load and simulate with different data files from Tekniska Verken
Result:	Passed with complementary work
Comment:	No consensus is used in file management. Some files are one year long others only one month. The program can not differentiate between them, but as long as files are the same length as initial, program works.
Approved by:	PK

Table 14: *Test 11 - Prediction of energy consumption*

Test number:	11
Goal:	Test that program can predict energy consumption
Requirement number:	29
Test description:	Load different energy consumption and evaluate how good the predictions are
Responsible person:	AB
Deadline (week):	46
Criteria:	The predictions should stay in 50 % of the actual energy consumption value for every hour
Result:	Passed
Comment:	The predictor uses historic data to predict future electricity consumption within the set accuracy limits. Only short data files were obtained for this project, which makes it difficult to evaluate predictor for longer time periods.
Approved by:	PK

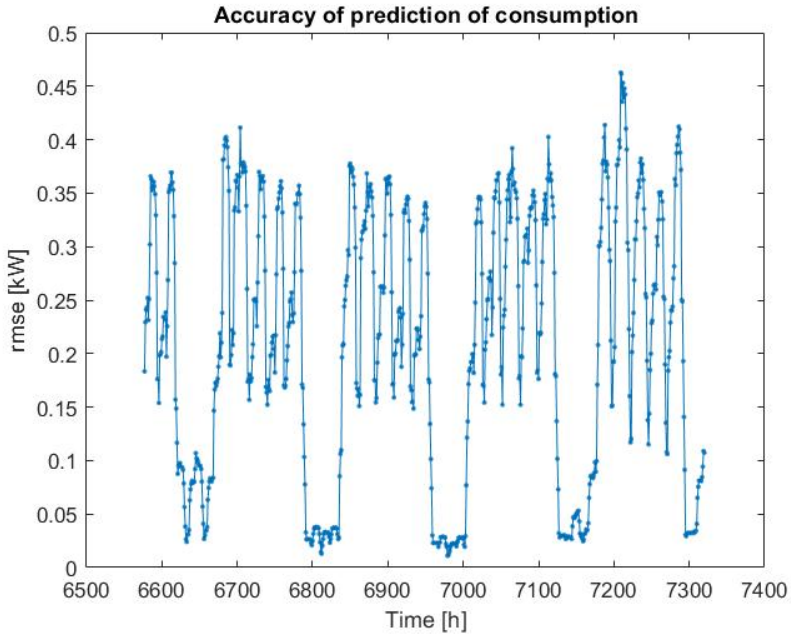

Figure 13: Mean square error of predicted electricity consumption for October 2020