# 2. Literature study

## Overview

The optimization of a residential electricity system requires knowledge regarding a wide field of disciplines. Several topics will therefore be researched thoroughly to establish what knowledge has already been studied and what knowledge we have to base further decisions on.

First we will establish basic information regarding the current residential electricity model. This will include the setup of the system at a residence; the current pricing structure, as well as expected future developments.

Next we will consider the typical considerations when a house is converted to carry PV renewable systems, as well as extending this setup to include batteries.

Scheduling loads carries hefty weight in itself as a subject of energy systems. We will consider what factors to consider as well as what constraints can be implemented when we go ahead with the optimization.

Optimization is a intriguing field of mathematical study, and requires some discussion in itself once the setup of the scheduling has been decided on.

Design of the hardware system that will be implemented require that we clearly know what we would require from the hardware. We will consider what physical and theoretical constraints we have, as well as how large economic factors play a role in the system.

## Residential energy systems

### Introduction

To identify where optimization can be applied in the residential electrical system, we familiarize ourselves with the setup that we can expect to practically be working with.

The thesis objective states that the optimization should consider renewable infeed, which gives some indication as to what lower limit we can consider for the system, i.e. we can assume that our system will not be implemented in a low-income system with only basic loads such as lighting.

### Typical Household Wiring

We establish a set of assumptions about the residential system that will be used to optimize schedules on.

As can be deducted from the objective of the Thesis, the residential system should carry PV panels for renewable energy infeed. We should provide for the possibility of energy storage (batteries is implied, but energy storage can also refer to storing of energy in hot water).

The optimization is to be done on appliances such as the swimming pool pump and the geyser.

Therefore, we establish the following baseline of the residential system: A system that contains uncontrollable and uncontrollable loads, with a renewable energy infeed used in conjunction with battery storage The system will be grid connected to allow for feeding surplus energy from the renewable source into the grid.

### Renewable household setup

The topic of this thesis is defined in terms of the electricity system of a residential setup; this requires that we define what residential setup we will work with.

To get an idea of how big the effect of our project is, define

1. How big the residential part is
2. How the residential is divided
3. How the typical house that we design for energy usage is defined

On the second demand vs average over half hour demand profile.

<Boek 1 geel flag>

Generating household profile data – noem net dat “although in itself, generating household profile data is an entire study, for our purposes of determining how effective optimization is is not too reliant on the profile. We construct a simple profile that is based on a suggested small household with rated appliances with predictable usage.

As the topic of research is optimization of loads, the most common loads that we can expect to optimize are the swimming pool pump and the geyser. Other loads that can be controlled is \_\_\_\_

Amount of energy usage per appliance and how large a part the geyser and the swimming pool takes of the total.

Renewable house setup – The SMA setup

The energy flow diagram showing how energy is distributed within the system

The TOU, and the setup whereby we assume that no money is received for delivering to the grid but money is paid to withdraw from the grid. HomeFlex system.

## Solar design and aspects

### Introduction

Designing a solar system for a residential customer is a challenge on it’s own and the myriad of considerations is beyond the scope of this document. We do however discuss the typical process and highlight important considerations that are relevant to the optimization within this document.

### PV panel sizing

PV panels aim to lessen the dependancy on grid-provided energy. During the da

### Battery sizing

Batteries can serve two main purposes in a renewable system:

1. Batteries provide backup power in case the grid cannot provide electricity
2. Batteries can improve the efficiency of the renewable system by storing surplus energy that would normally be fed back into the grid. It can also supply energy for small durations of cloud cover and recharge immediately as soon as the clouds pass. (VOORBEELD VANAF SMA dokumente)

The economics regarding the battery were not considered in the design of this thesis, but from research it is clear that battery cost is too high to be justified by the efficiency increase that it brings to the system. The main reason that batteries are introduced to the system is for the ability to provide backup power in case of power outages.

Battery sizing is determined by the amount of load it has to be able to carry for a specified amount of time. A simple design example would look like the following: [SIT VOORBEELD VAN N DESIGN HIER IN]

## Scheduling as system optimization

### Introduction

Scheduling can be subjected to a vast amount of constraints and conditions. These constraints and conditions can often be identified from a written description of the system.

This topic considers methods of optimizations that has been previously used and what scheduling factors were considered in the analysis.

After other research has been studies, an appropriate model will be chosen for our optimization, as well as the constraints that we will apply to the scheduling setup.

### Problem definition

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As discussed in [DIE HOOFSTUK WAT LASTE BESPREEK] we will consider our schedulable loads as the swimming pool pump and the geyser.

Knowledge of the basic operation of these appliances allows us to define what measures we would like to implement.

We will run optimizations for different sets of measures that will allow us to study the effect of the measures we implement on the efffectivity of the optimization.

### Optimization from previous

### Optimization method and cost function

### Static versus dynamic optimization

The aim of the thesis is “optimal scheduling of load and storage operations” [AANHALING UIT OPDRAG].

Optimization would typically require the following aspects:

Definition of the system as per the parameters that needs to be optimized

The boundaries and constraints that the parameters are subjected to

The value of the parameters initially, before optimization is applied

The object function or cost function, which defines what we are trying to minimize.

These specifications can be stated in informal terms, describing the system. However, to apply this to optimization, these need to be converted to mathematical entities that we can apply to a suitable mathematical optimization algorithm.

It is important to note that the thesis does not specify to what purpose the optimization needs to be done. Optimization for one purpose would almost certainly not give the same parameters as for another optimization e.g. optimization to minimize cost to the owner and optimization to minimize peak loads for the utility would deliver different results.

We will need to determine how the problems need to be set up for different optimizations

Furthermore, we will assume the aim of the optimization is minimizations of cost to the owner.

## Scheduling hardware design

Hardware

To perform optimizations

To hold schedule

To switch loads on and off

The hardware needed to switch loads on and off

What wireless systems exsist