Methods for Enhanced Automated Load Shifting Analysis

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Background and Motivation

By the increasing share of renewable energy sources (RES) in the electric energy generation mix, also the amount of non-controllable power generation in contrast to conventional controllable power plants rises. To integrate this increasing amount of predictable RES into the mix of generation, smart solutions like Demand Response (DR) have to be enforced to be able to handle the fluctuating and intermittent power generation.

Existing approaches for DR are offering a specific amount of electric energy to be shed or shifted in time. This can be done with flexible loads like HVAC, cooling devices, pumps, or any other appliance with (thermal or potential) storage characteristics. In the project GAVE a manual solution for load shifting has been proposed and successfully tested.

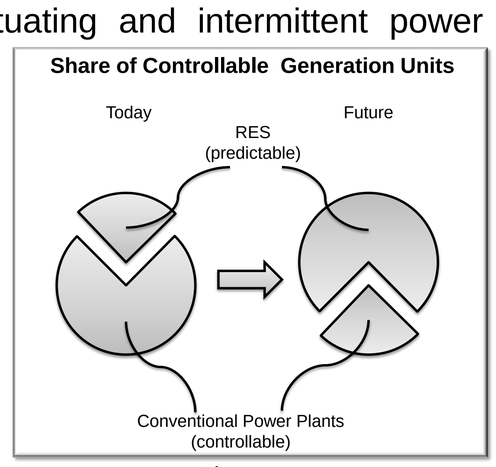

Figure 1

The problem of the GAVE solution is, that for DR applicability of the pumps and the HVAC systems, a huge amount of data has to be processed manually by an engineer. This high effort and manual intervention makes it uneconomic to integrate such DR applications.
Thus the motivation for this work is the presentation of methods and approaches for automated load shifting analysis, which should be build up on the manual method.

Manual Load-Shifting Methods

Goal

The operator must find a way to shift loads among several water pumping facilities in order to satisfy a given load shifting plan.

Data analyzed

- Energy consumption of the pumps on daily basis (cf. Figure 2)
- Water pumping activity during the day (cf. Figure 3a)

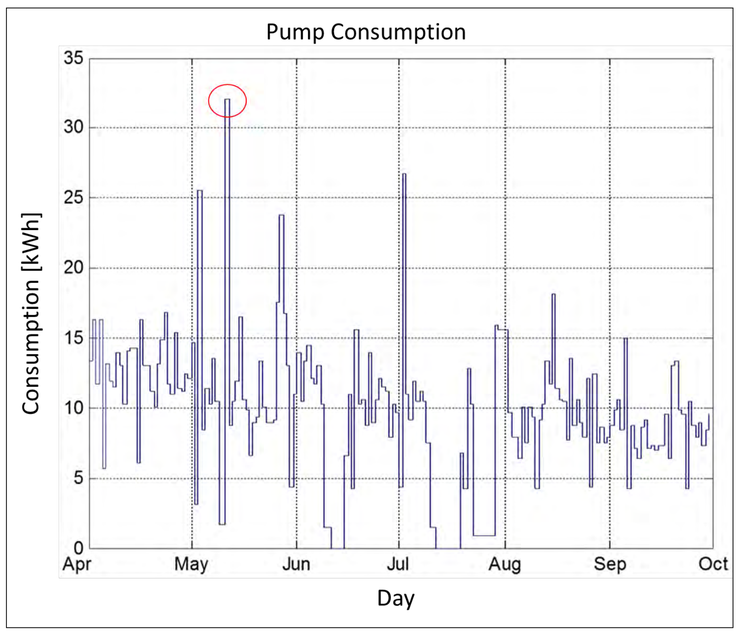

Figure 2

Method description

A typical load-shifting plan demands minimization of the pump consumption at peak hours, for example between 12:00-13:00. So the operator has to shift the power demanded by the pumps by pre- and post-conditioning be-fore and after this time frame. This is depicted in Figure 3b.

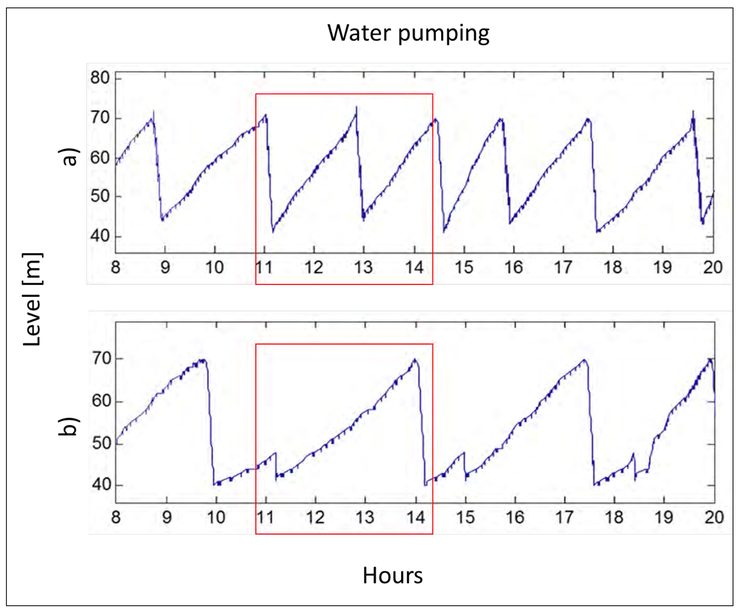

Figure 3

Proposed Methods

The main goal is to replace the manual load shifting potential examination by an automated methodology, utilizing historical big data of the appliance. For that purpose the following steps will be applied:

- Step 1: Requirements for an algorithm to replace human operator: The workflow of a trained human operator has to be analyzed as well as the decision process of the operator
- Step 2: Search for a prediction algorithm (e.g. machine learning)
- Step 3: Prototype implementation, evaluation of algorithms and selection of the one best suited
- Step 4: Data aggregation and preparation
- Step 5: Algorithm training, adaptation and tests

The algorithms are searched in the field of:

- Extreme Learning Machine, in case of a model based approach
- Pattern recognition, in case of a base approach

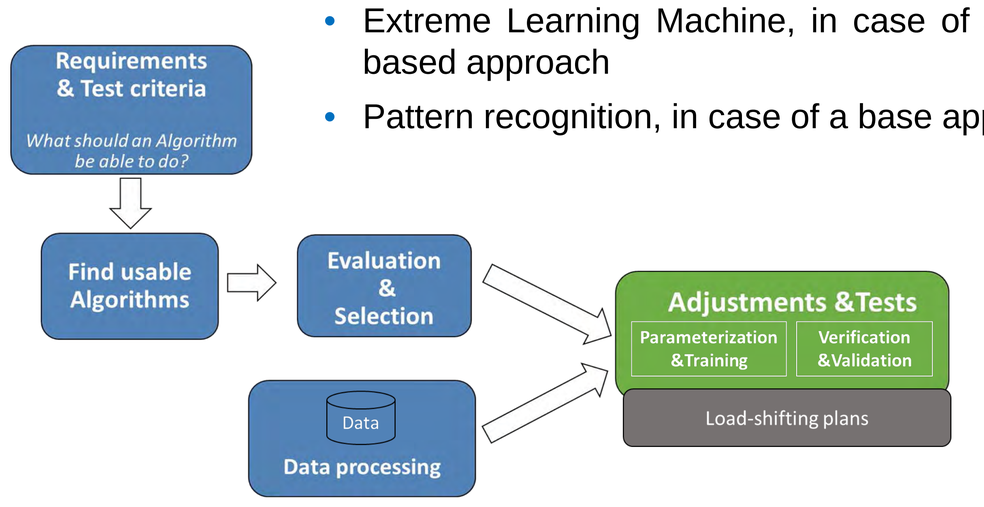

Figure 4

Expected Results & Benefits

The resulting method for enhanced automated load shifting analysis consists of three major modules which form the basic elements of the conceived aDSM Agent (depicted in Figure 5 – on the example of the suggested GAVE project extension).

- Data preparation for merging and consolidating of both
  - live input data
  - historical input data
- Prediction algorithm for processing
  - preprocessed live and input data
  - load displacement plan provided by the energy utility
  - prediction algorithm settings and configuration
- Decision unit for matching the load shifting potential with the provided load displacement plan and forwarding the results to the appliance

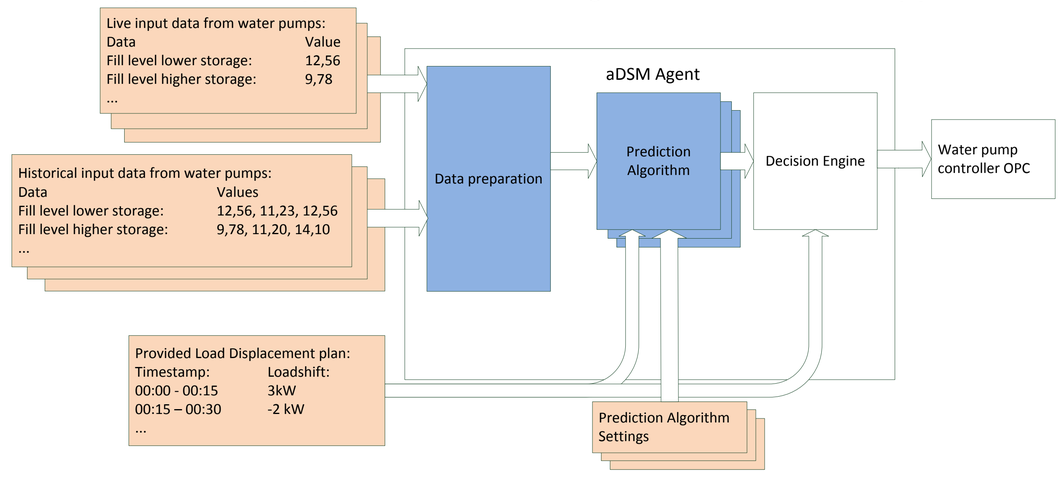

Figure 5

Expected benefits of this solution are the

- reduction of engineering costs,
- the facilitation of DR integration, and
- maximization of DR potential by the automated algorithm.

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