Exploring system efficiency in smart homes: early experiences from a smart home and digital twin in a controlled lab environment

Georgios Foskolos and Peter Bennich

The Swedish Energy Agency

Presented by Nils Borg, Borg&Co

EEDAL 2024-10-08

Agenda

- Background
- The smart home
  - Set-up
  - Example of measurements
- The Digital twin
- Initial conclusions
- Future work

Testlab – Smart Home lab

Swedish Energy Agency

Purpose

- **Interoperability issues?**
  - Can any smart hub be used with the appliances in the smart home (and vice versa)
- **What are the energy and power requirements of connected products?**
  - Compare the individual stand-by use of products with the stand-by use of the system.
- **How do products behave within a system? Are there irregularities or disturbances that are not considered and can lead to undesirable behavior or energy use?**
  - Create and run simulations of different use cases that can be run for different settings and systems.
- **Which parts of the system or use case require the most energy/power? Are there critical areas suitable for control?**
  - Create and run simulations of different use cases that can be run for different setups and systems.

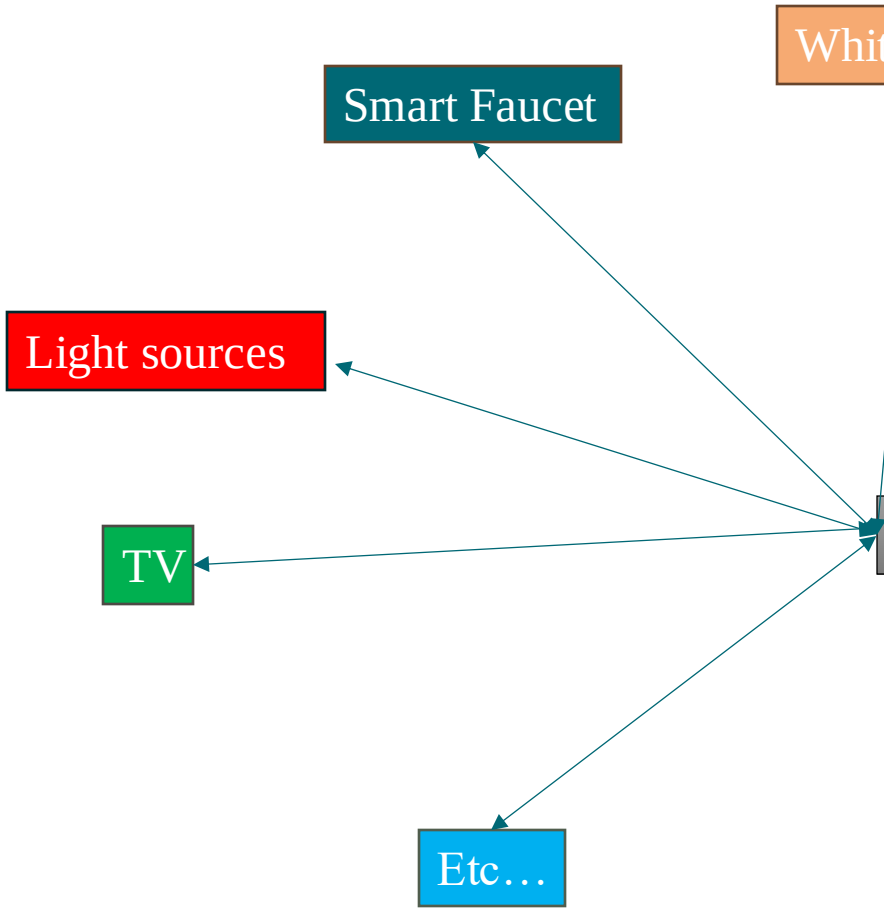
Purpose - cont

- **How much, where and when is data sent between products and with other parties?**
- **Is the amount of data required reasonable in relation to the function?**
- **Can the results be used as input for standardisation and policy?**

- **At this early stage - Proof of concept:**
  - Can we measure traffic between devices?
  - Can we measure traffic to the outside?
  - Can we measure the energy/power of several devices simultaneously?

Smart Home lab measurements

7 channel WT5000
Measuring electrical properties



- Homey Pro
- Ikea Dirigera
- Google Nest Hub Max
- Home Assistant

WIRESHARK

Ubiquiti

Data analysis - mirroring data traffic

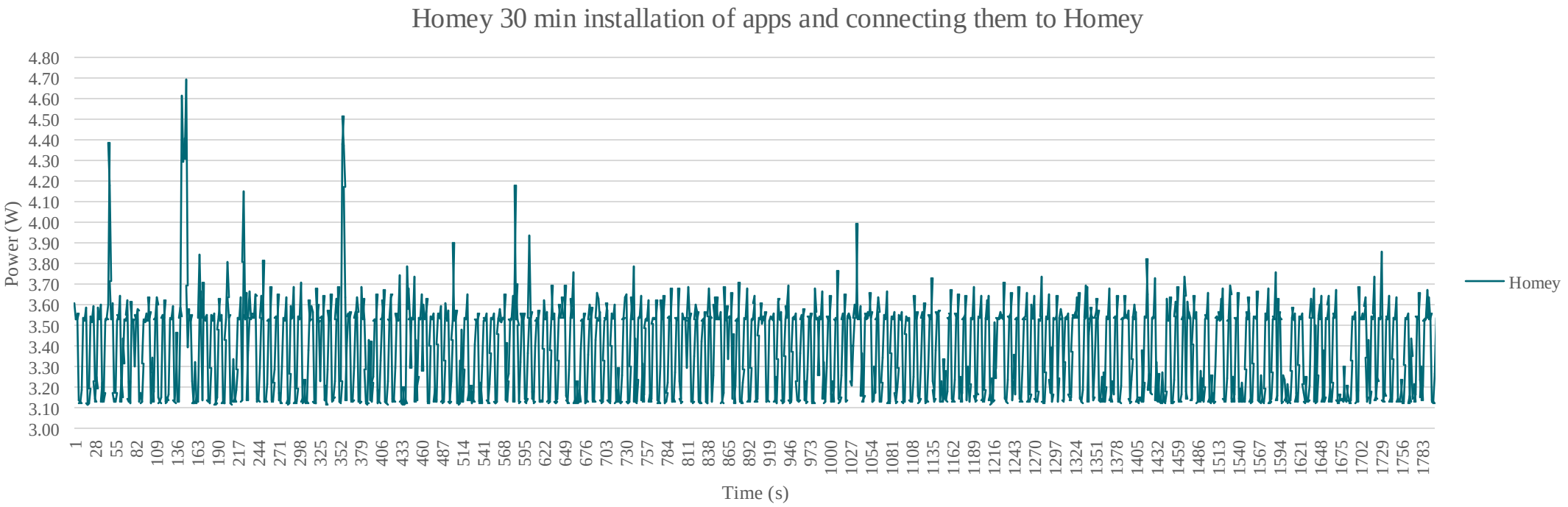
Swedish Energy Agency

Test of Homey

[Homey Pro - the world's most advanced smart home hub.]

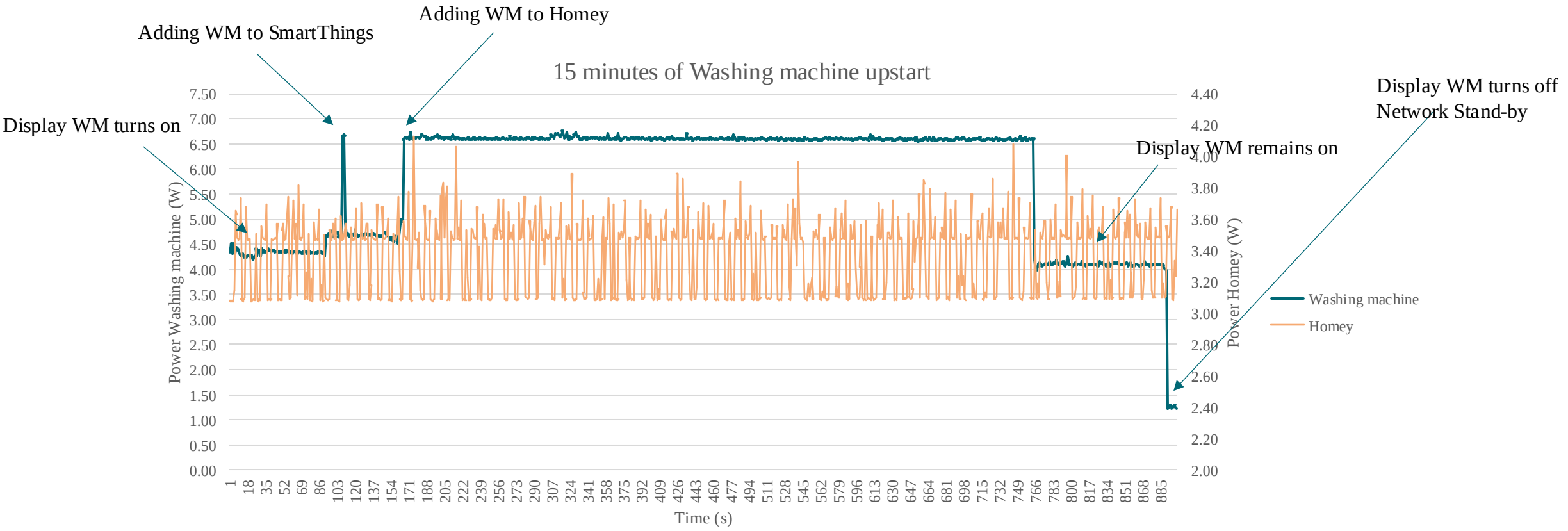
Swedish Energy Agency

Homey: installation sequence



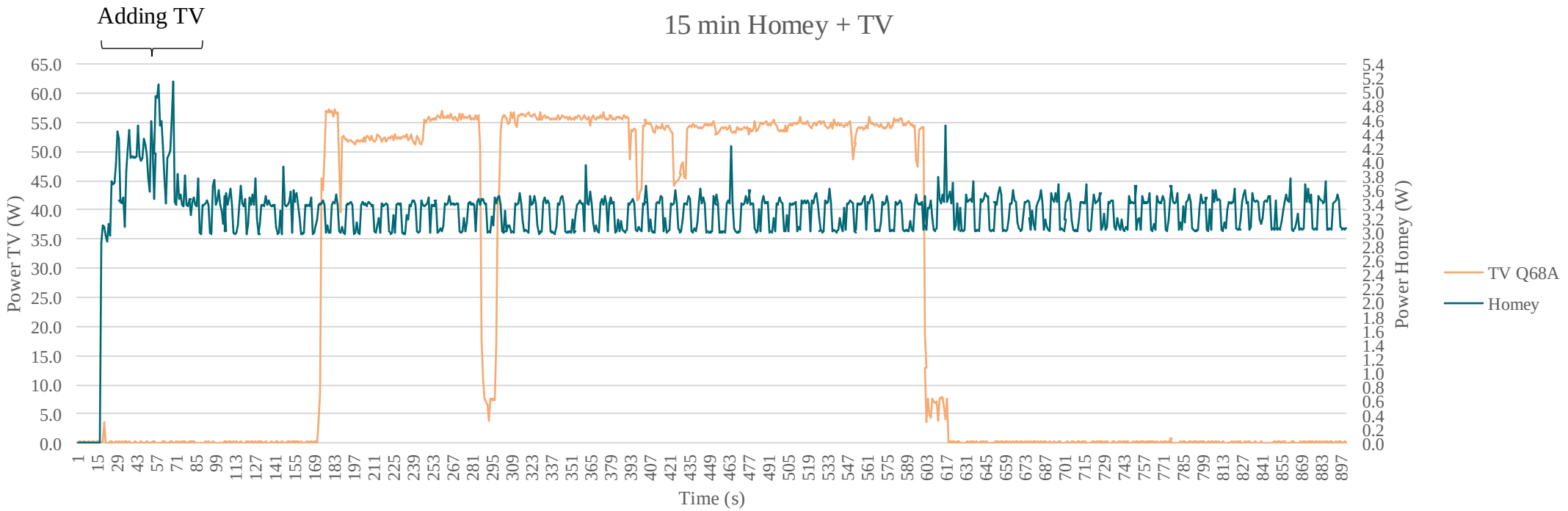
Swedish Energy Agency

Connecting Homey and Washing machine



Swedish Energy Agency

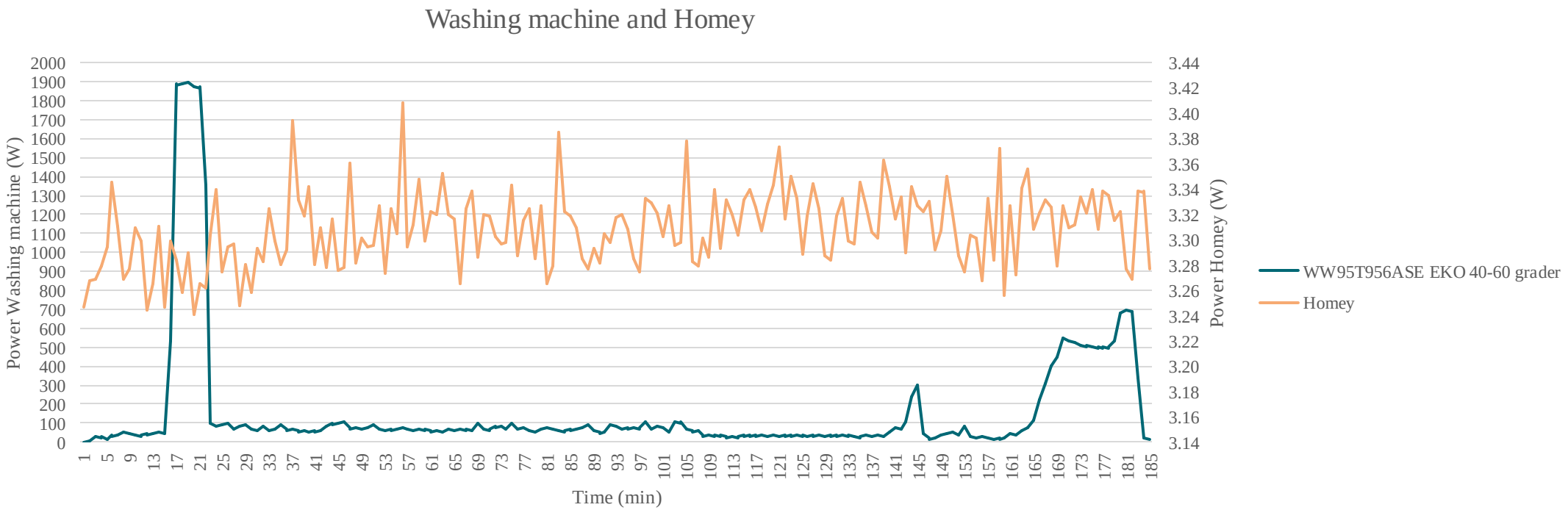
Homey and TV



Booting Homey Pro and added TV. Quick and easy to add the TV.
Turn on, off and on TV and adjust volume via Homey.

Swedish Energy Agency

Homey and Washing machine



ECO - 40-60 degrees together with Homey - no control can be done, but you can see the status
- Laundry in progress, remaining time and progress (%).
The machine detects how well the machine is filled and then tells you how long the program will take

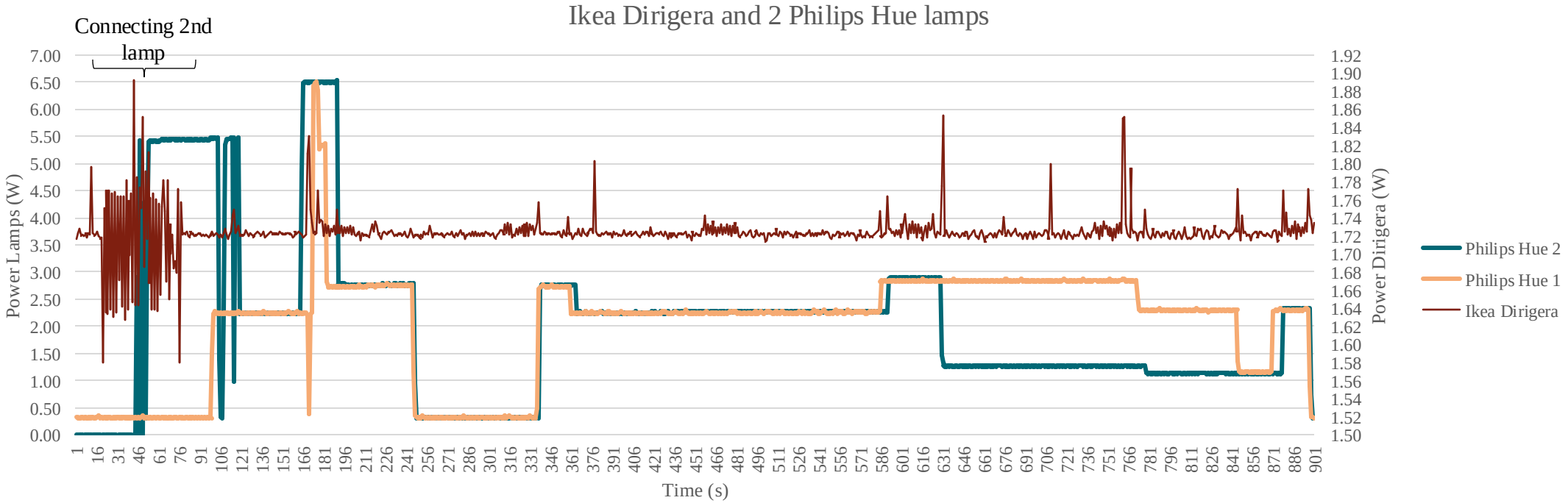
Swedish Energy Agency

Test of Ikea Dirigera

DIRIGERA hub for smart products, white smart - IKEA Sweden

Swedish Energy Agency

Dirigera: Installation and control of lamps



1st lamp has already been added. Added a 2nd lamp so it can also be controlled with the Ikea Smart Home app. The light turns on and off according to instructions and is easily found! Control, dimming turning on/off, changing color.

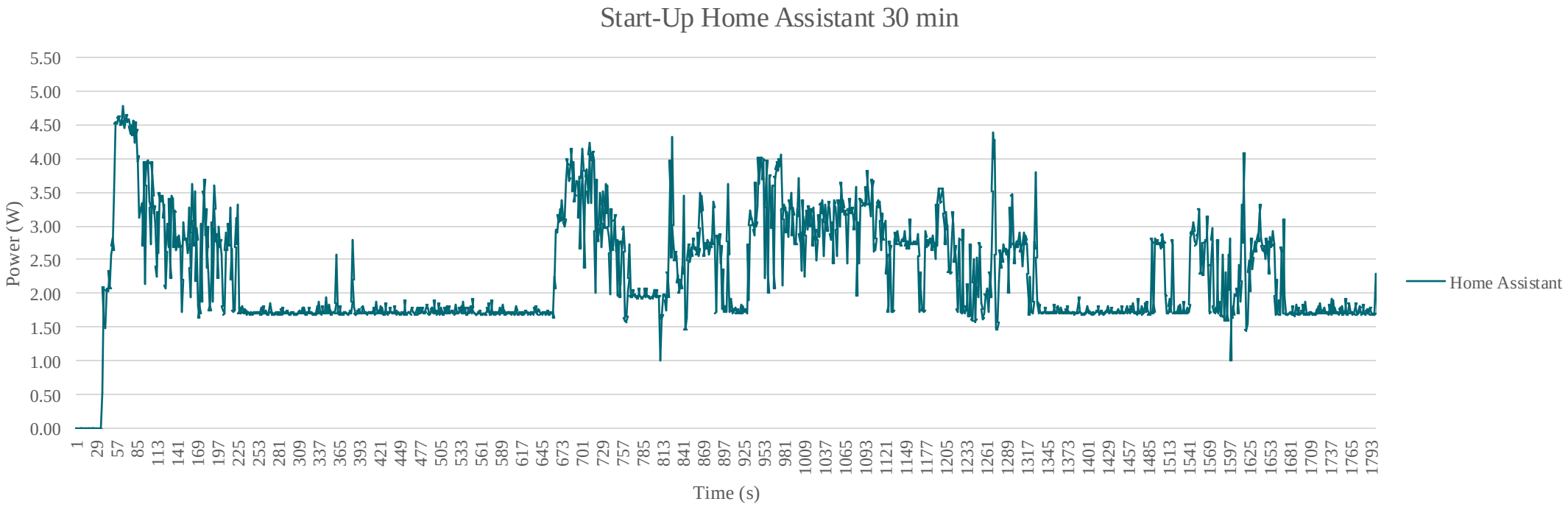
Swedish Energy Agency

Test of Home assistent

Home Assistant (home-assistant.io)

Swedish Energy Agency

Home assistant: Installation sequence



Start-up, updates, restarts

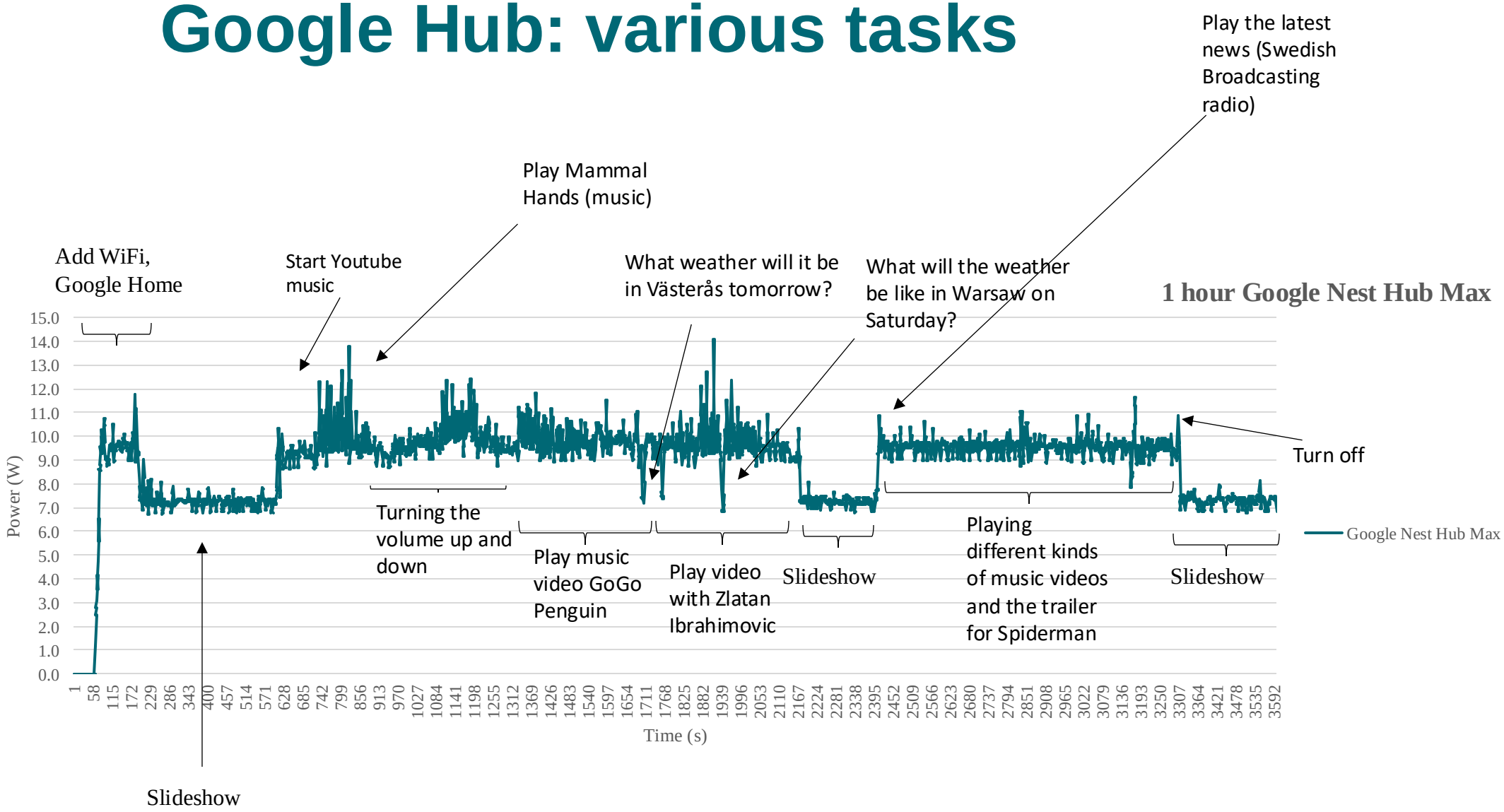
Swedish Energy Agency

Test of Google Nest Hub Max

[Introducing Google Nest Hub Max - Google Nest Help]

Swedish Energy Agency

Google Hub: various tasks



Swedish Energy Agency

Smart Home lab – the basis of a *digital twin*

- A virtual copy of a physical object or system and its associated environment
- A possibility to simulate and visualize operational scenarios

- Phase 1: Creating the simulation environment (Python)
  - Set up an object-oriented environment with the *aim of mimicking* the Smart Home
  - The work package includes the creation of a scalable object-oriented solution

- Phase 2: Strategies for consumption smoothing
  - Development of strategies to reduce power peaks and flattening the consumption curve
  - Simulation with scheduling

Initial conclusions

- Smart Home:
  - Methodology:
    - A *systematic* way of testing *combinations* of a smart hub and appliances connected to it, seems to work with respect to *power and energy*
    - Time resolution has to be chosen carefully (to capture fast processes)
    - Measurements of the *data flow* remains to be explored
  - Results
    - Early results indicate that the energy use is relatively low for the actual connectivity – or is it? To be discussed!
- Digital twin:
  - Early stage – mirroring the Smart home

Future work

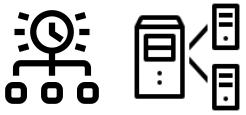
- Smart home
  - Explore data traffic related to instructions and power use
  - Connecting more devices

- Smart Home and Digital Twin working *together*
  - Phase 3 (*next slide*)

Phase 3 and beyond…

Smart Home lab

- Measurements at Testlab
- Load curves from external labs and home environments



- Simulate behavior and analyze aggregation

- Simulate multiple houses, multiple apartments, streets, city...

- New loads: batteries, PV, EV...measurement data from manufacturers, external tests

- Impact on the electricity grid
- Flex
- Large-scale scenarios

Swedish Energy Agency

Swedish Energy Agency

Georgios Foskolos
Technical advisor at Testlab

georgios.foskolos@energimyndigheten.se

Visit us on
www.energimyndigheten.se/en