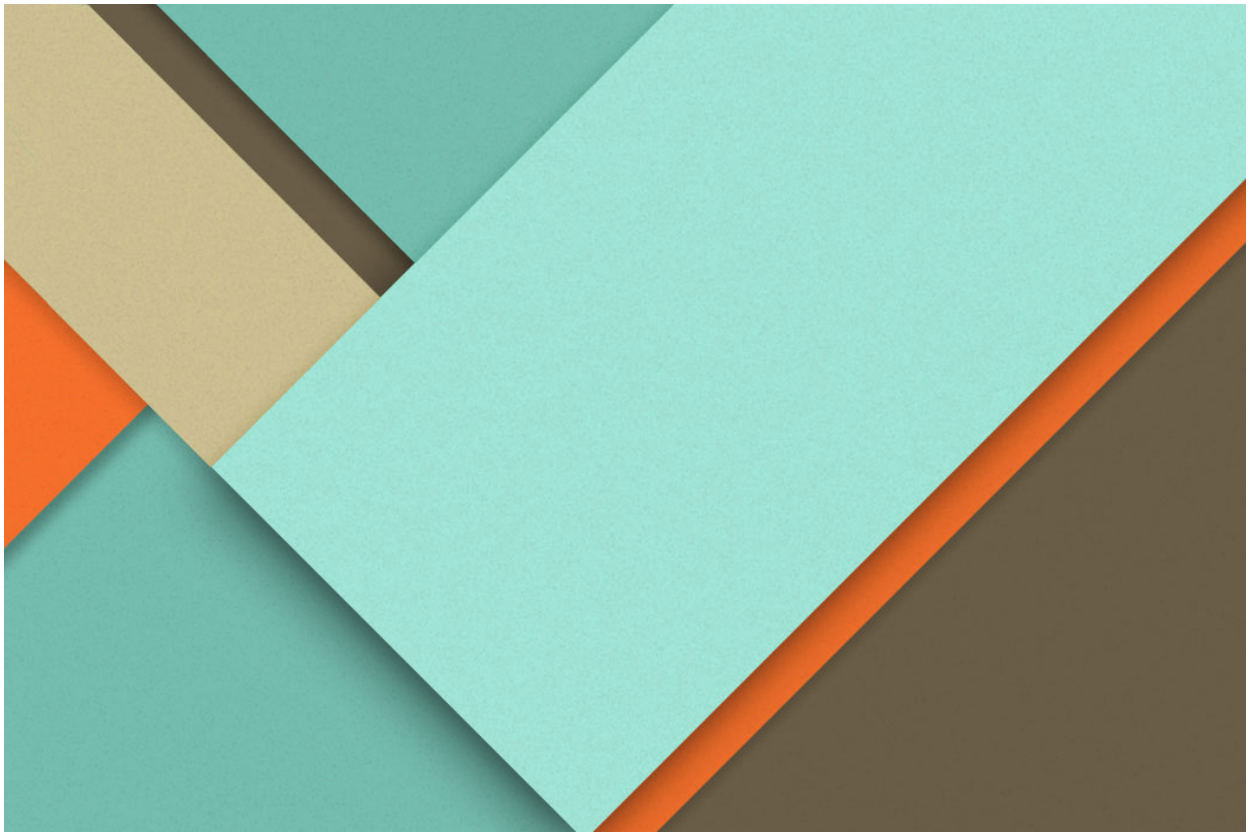

Project proposal: Smart Homes Energy Management

14.11.2019

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IoT Analytics

IoT Analytics is a strong company working in the sector of Smart Home Energy Management (SHEM).

Background

"Home Developer SRL" (HD) is a developer and provider of smart homes. Aiming to improve energy efficiency of their smart homes, HD have contacted IoT Analytics.

With ever increasing electricity prices and CO2 emissions, energy efficiency is a very important topic. It helps both at saving energy cost and reducing CO2 pollution.

HD have delivered data of one of their smart homes located in Sceaux, France and for the period between December 2006 to November 2010. It contains energy consumption data of three separate sub meters installed in different rooms of the house: kitchen, laundry and HVAC room. The overall power consumption of the house is also available. The data is available as 1-minute-average for each minute. The appliances covered by the sub-meters are the following:

Sub-meter	Appliances
1 (kitchen)	Dishwasher, Oven, Microwave
2 (laundry)	Washing machine, Tumble drier, Refrigerator, Light
3 (HVAC)	Water heater, HVAC
4 (rest)	Rest: lights, TV, others

Motivation

The following proposal explains how IoT Analytics can help “Home Developer SRL” to leverage power usage analytics, in order to offer Smart Home Energy Management (SHEM) systems in their smart homes. The SHEM will in turn allow the final user to optimize the energy efficiency and hence save energy and costs.

Objectives

1. Provide power usage analytics of sample smart home provided by “Home Developer”
2. Describe the SHEM offered by IoT Analytics
3. Provide the project plan including timeline
4. Provide commercial proposal

Benefits of SHEM

Some of the information provided by the SHEM and their benefits are:

1. Scheduling working hours for specific appliances (i.e. washing machine) to control load profile → potential cost savings combining with a dynamic electricity tariff
2. Identifying “big energy consumers” → potential energy savings by exchanging with smart devices (high efficiency appliances)
3. Monitoring the condition of specific appliances → energy savings by maintenance/replacement of defective appliance (i.e. filter replacement of HVAC, defective sealing in refrigerator)

Power usage analytics of sample smart home

In the following pages some practical benefits of SHEM applied on the sample smart home are presented.

1. Energy consumption Summary

A summary of overall energy consumption of the sample house is shown below.

year	total (kwh)	kitchen (kwh)	laundry (kwh)	HVAC (kwh)	rest (kwh)
2007	9713	642	854	3022	5194
2008	9415	584	661	3180	4989
2009	9370	592	592	3555	4630

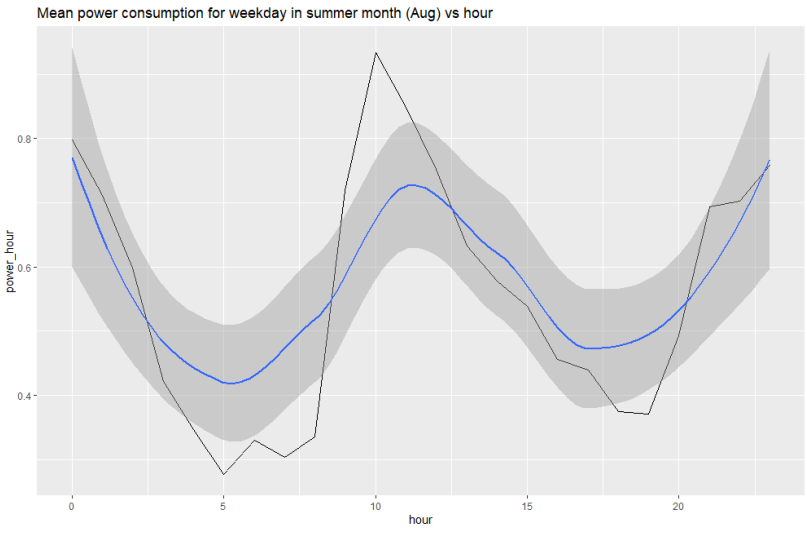
As can be seen most of the consumption happen in the rest of the house. **To take the real benefits in energy and cost savings SHEM can offer, additional sub-meters are needed in order to cover the other areas of the house.**

2. Daily power consumption

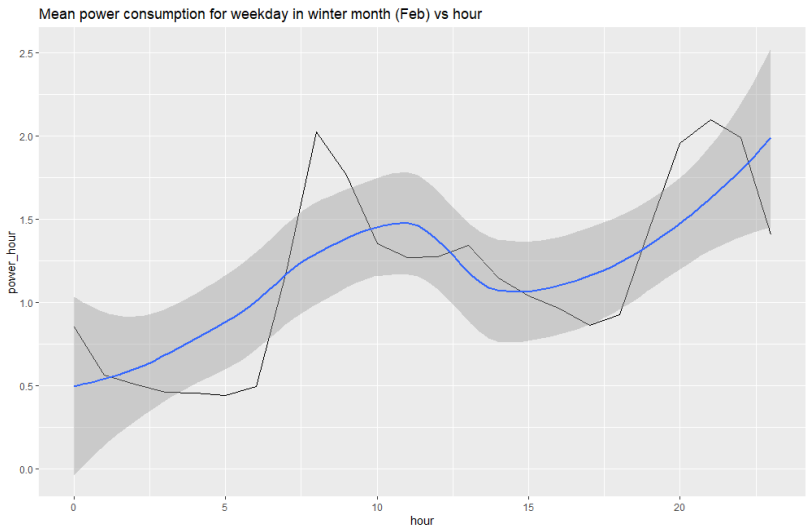
With the help of daily overall power consumption the end-user can:

1. Identify max power consumption (peaks) and min power consumption (valleys)
2. Understand electricity usage behavior
3. Choose the right electricity tariff in order to save energy costs

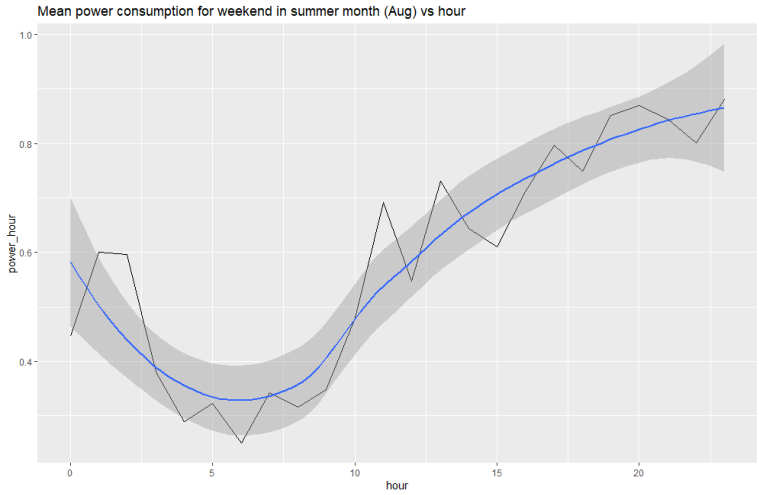
In the figures below the hourly overall power usage of an average day is shown.



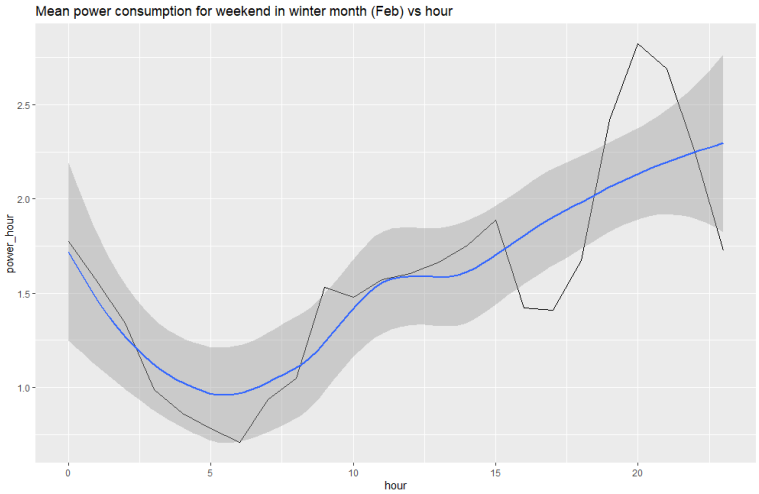
Overall power usage hourly on an average weekday in summer. Two peaks can be appreciated at 10am and at midnight.



Overall power usage hourly on an average weekday in winter. Also two peaks can be appreciated one in the morning and one in the evening.



Overall power usage hourly on an average weekend day in summer. One peak can be appreciated at late in the evening.



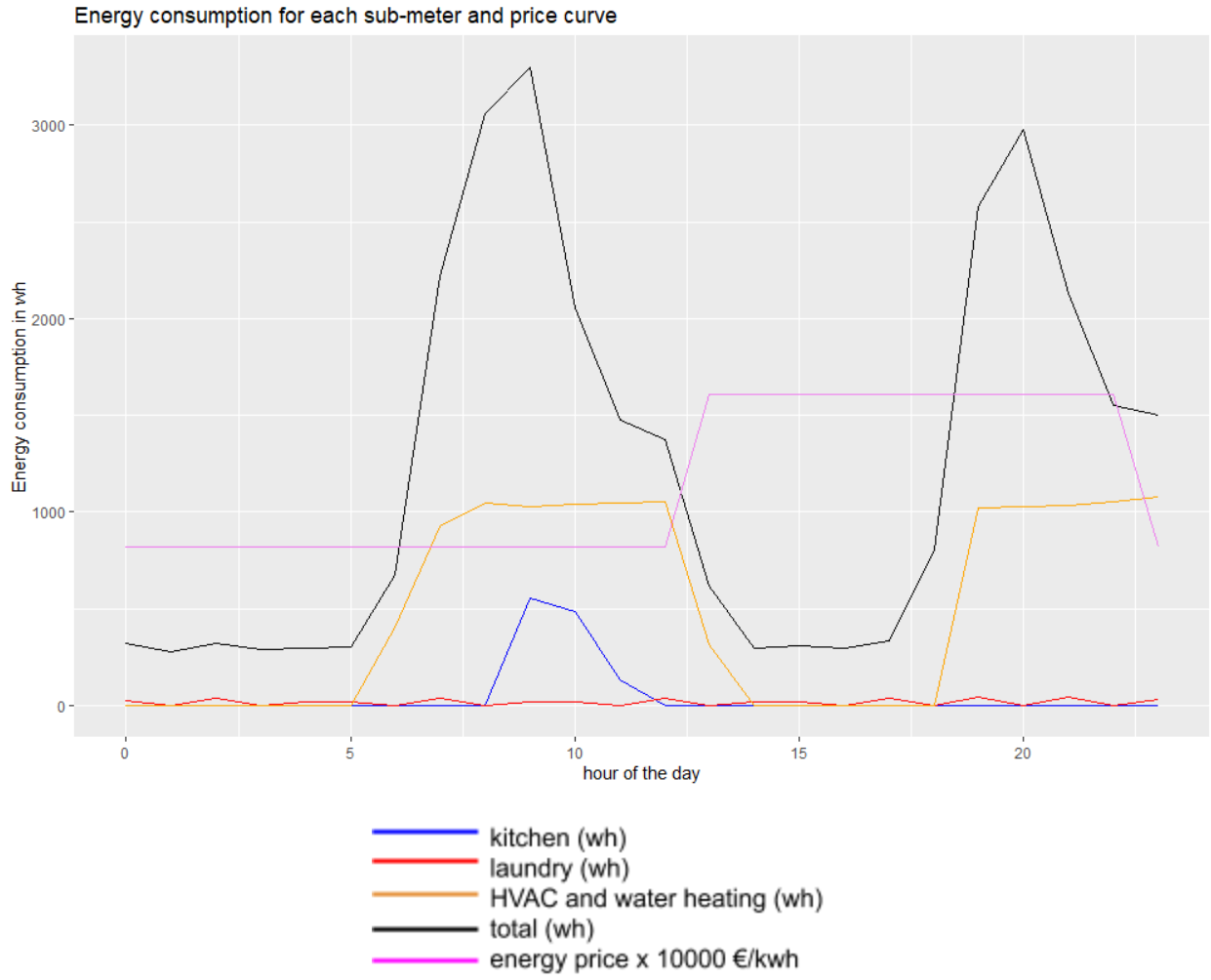
Overall power usage hourly on an average weekend day in winter. One peak can be appreciated at late in the evening.

By knowing and understanding its own consumption behaviour the end-user can look for the electricity tariff option which balances better the consumption and in this way pay less electricity at the end of the month.

The load curve can also be a motivation to change own consumption behavior (reduce the peaks of the curve)

3. Daily energy consumption per sub-meter

Another useful visualization possible with SHEM is the hourly energy consumption per day of each sub-meter and the total. By adding the electricity tariff plan (in this case just informative) useful information can be obtained. Below this type of visualization is shown for one example day for the sample smart home.



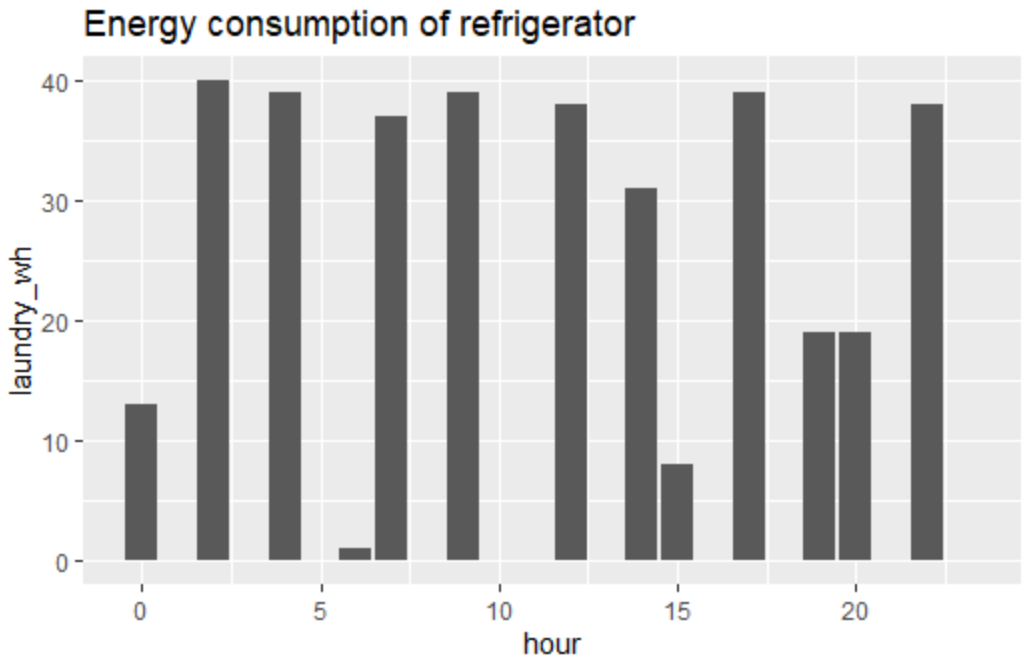
Based on the example visualization above, the end-user can see the hourly energy consumption for each room of the house (each sub-meter), the total energy consumed in the day together with the price per kwh. The end-user can get the following insights:

- Most consumption came from HVAC and water heating → reduction in the energy consumption possible by changing to gas powered water heating or higher efficiency HVAC
- The tariff plan is appropriate for the consumption behavior, since the energy peak occurs during the "valley" part of tariff curve → optimal tariff plan.

Although in this case an individual day is shown, the monthly average is also available in order to make decisions upon whether to stay or to look for more optimal tariff plan.

4. Condition monitoring of appliances based on changes in power consumption

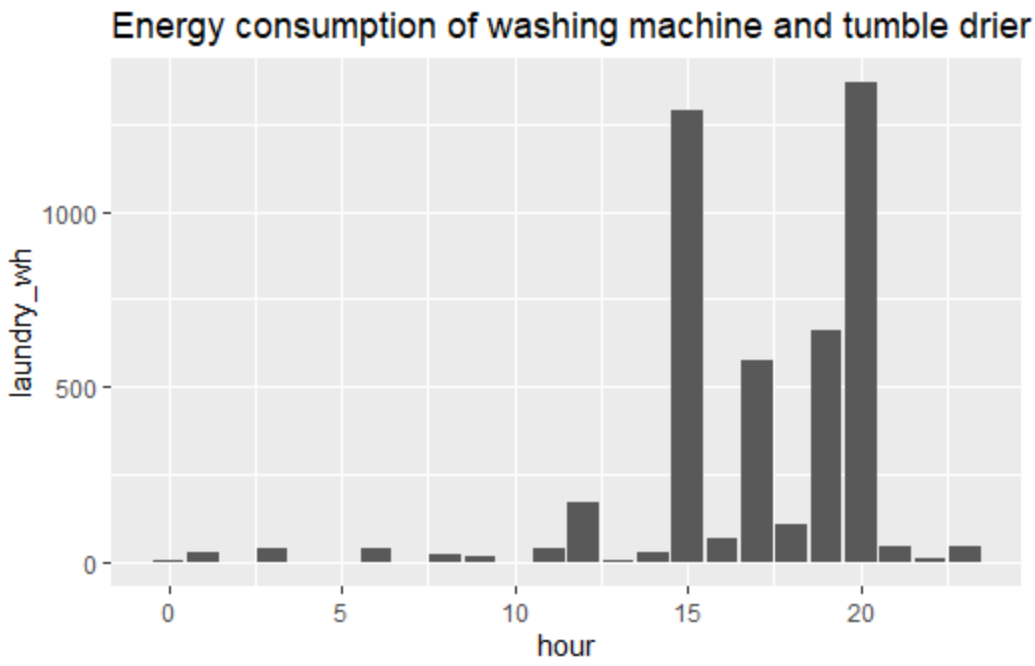
It is possible to identify specific appliances based on their energy consumption patterns. For instance, in this example of the sample house the energy consumption of the refrigerator for an example day can be seen. Refrigerators turn on and off at regular intervals depending on the thermostat setting in their interior. In the figure below a clear pattern representing the refrigerator can be appreciated.



The condition of the refrigerator can be monitored day per day, month after month, year after year. If abnormal increase in the power consumption is detected, a maintenance or even exchange of the appliance is recommended in order to regain energy efficiency.

5. Identification of "big" consumers

SHEM can also offer the identification of "big consumers". In the example of the sample house below, the consumption of the washing machine and tumble drier can be inferred in the high peaks.

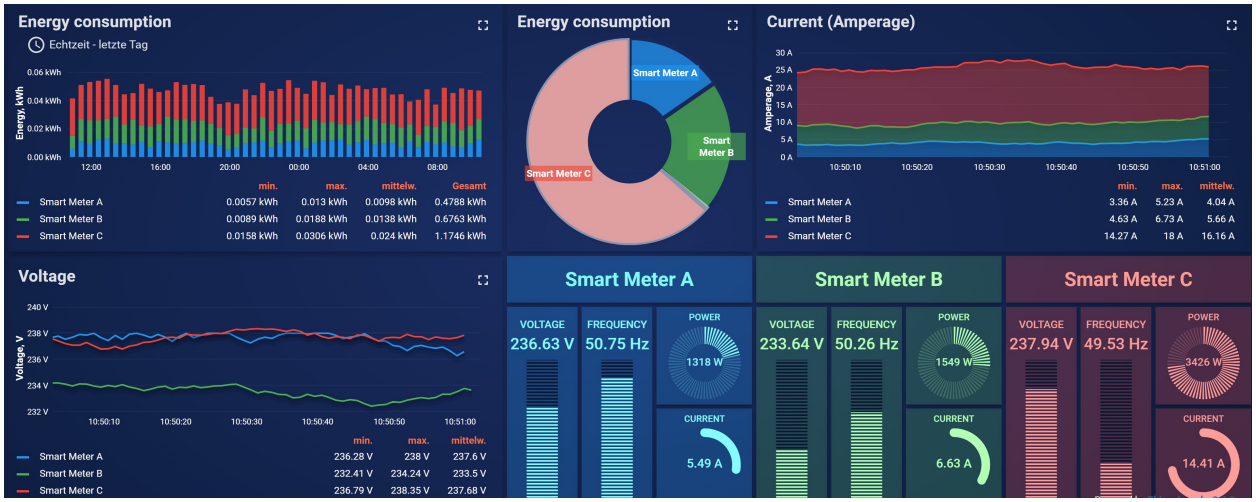


Description of the SHEM

The SHEM offered by IoT Analytics consist of an interactive dashboard providing energy and power consumption analytics. The analytics shown in the dashboard are the following:

1. Energy consumption summary: energy consumption share for each sub-meter
2. Daily power consumption
3. Daily energy consumption per sub-meter
4. Mean, max and min power consumption of the month
5. Comparison day-to-day and month-to-month
6. Condition monitoring of selected appliances based on changes in power consumption
7. Comparison of energy consumption and energy tariff
8. Predictions on energy consumption

An example of a dashboard is shown below only for informative purposes and is not binding.



(example of a SHEM dashboard)

Requirements to the project

1. Sub-meters need to be installed in order to cover all areas of the house.
2. Big consumers should be monitored separately with dedicated sub-meters:
    a. Washing machine and tumble drier
    b. Water heater
3. The tariff plan options can be provided by the customer

Data management

The provided data will be protected as per current GDPR regulation.

Project plan

Deliverables	Timeline	man hours	price per man hour	Total (eur)
Dashboard: - Energy consumption summary: energy consumption share for each sub-meter - Daily power consumption - Daily energy consumption per sub-meter - Mean, max and min power consumption of the month - Comparison day-to-day and month-to-month - Condition monitoring of selected appliances based on changes in power consumption - Comparison of energy consumption and energy tariff - Predictions on energy consumption	15.11.19 - 27.11.19	72	50	3600
API for proccessing input data in real-time				1800
Total				5400

Additionally: 10 EUR x month x house for the real-time providing of the service

Additional features (optional)

As an option, IoT Analytics can offer the following additional features, provided the required data is made available and in good quality and an additional commercial agreement is closed. The additional features are:

1. Schedule optimal ON/OFF status of appliances based on input electricity tariff
2. Include Energy storage
3. Include self-consumption (solar/wind)
4. Day-ahead-price predictions

Schedule On/Off of “big consumers”

Requirements

1. One additional smart meter needs to be installed to monitor the “big user”. Normal share of electricity consumption in a household is the following:
    - Water heater: 14% of energy use.
    - Washer and dryer: 13% of energy use.
    - Lighting: 12% of energy use.
    - Refrigerator: 4% of energy use.
    - Electric oven: 3-4% of energy use.
    - TV, DVD, cable box: 3% of energy use.
    - Dishwasher: 2% of energy use.

    - Computer: 1% of energy use.
2. Electricity price curve

Deliverable

1. Dashboard showing energy consumption of all sub-meters together with electricity price curve.
2. Energy cost of the day per sub-meter

Benefit

End-user is able to reschedule working hours of selected appliance by comparing energy costs and achieve in this way energy savings.

More detail regarding the other options can be provided after request.