Supply Side and Demand Side

Practical Course: Smart Energy Systems

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Weather Service

Weather Service

Weatherbit.io

- Free online weather service
- API Key needed
- Two APIs for gathering weather data
  - Current weather: https://api.weatherbit.io/v2.0/current
    - Query String parameter: key, lat, lon, units (optional)
  - 24 hours weather forecast on hourly basis: https://api.weatherbit.io/v2.0/forecast/hourly
    - Query String parameter: key, lat, lon, units (optional)
- 1000 requests per day

Weather Service

Weatherbit.io


```json
{
    "data": [
        {
            //...
        }
    ],
    "city_name": "Shanghai",
    "lon": 121.47,
    "timezone": "Asia/Shanghai",
    "lat": 31.23,
    "country_code": "CN",
    "state_code": "23"
}
```

```json
{
    "wind_cdir": "WNW",
    "rh": 56,
    "pod": "n",
    "timestamp_utc": "2018-11-08T12:00:00",
    "pres": 1020.82,
    "solar_rad": 0,
    "ozone": 281.7,
    "weather": {
        "icon": "c02n",
        "code": 801,
        "description": "Few clouds"
    },
    "wind_gust_spd": 9.31623,
    "timestamp_local": "2018-11-08T20:00:00",
    "snow_depth": 0,
    "clouds": 8,
    "ts": 1541678400,
    "wind_spd": 5.18777,
    "pop": 0,
    "wind_cdir_full": "west-northwest",
    "slp": 1021.87,
    "dni": 0,
    "dewpt": 4.7,
    "snow": 0,
    "uv": 0,
    "wind_dir": 290,
    "clouds_hi": 0,
    "precip": 0,
    "vis": 24.1,
    "dhi": 0,
    "app_temp": 13.1,
    "datetime": "2018-11-08:12",
    "temp": 13.1,
    "ghi": 0,
    "clouds_mid": 0,
    "clouds_low": 8
}
```

WeatherCollector

Data used

- `lat`: Latitute
- `lon`: Longitute
- `timestamp_utc`: UTC Timestamp
- `rh`: Relative humidity in %
- `pres`: Air pressure in mb
- `wind_spd`: wind speed in m/s
- `temp`: Temperature in Celsius
- `ghi`: Global horizontal solar irradiance in W/m^2

WeatherCollector

Two HTTP REST endpoints

- Create new WeatherCollector object by location
  - Path: POST /weathercollectors
  - Body as application/json: { "lat" : <lat>, "lon" : <lon> }
  - Response as application/json:
    { "lat": <lat>, "lon": <lon>, "id": <id> }
  - Response status code: 201, 400
- Delete WeatherCollector object of given location
  - Path: DELETE /weathercollectors
  - Body as application/json: { "id": <id> }
  - Response status codes: 200, 400

Windturbine

Windturbine

Energy produced:

- 0.5 * areaSwept * moistAirDensity * windSpeed^3 * efficiencyCoefficient

Area swept:

- r^2 * PI

Windspeed and efficiencyCoefficient :

- User Input

Windturbine

Moist air density:

- Compound of dry air and water vapor and their respective densities
- Depends on:
  - Temperature
  - Pressure
  - Relative humidity
- Formula: $d_{humid} = \frac{p_{dry}}{R_{dry}*T} + \frac{p_{vapor}}{R_{vapor}*T}$
  - d = density
  - p = pressure
  - R = specific gas constant

Windturbine

Partial pressure of dry air and water vapor:

- Total pressure -> Partial pressure of dry air + partial pressure of water vapor
- Partial vapor pressure computable with the formula:
  – Relative humidity * saturated vapor pressure
- Partial dry air pressure:
  – Measured air pressure – partial vapor pressure
- Saturated vapor pressure:

  => Herman Wobus equation, only depends on the Temperature and a lot of constants

Photovoltaic

Photovoltaic

Energy generated:

- module area * solar panel yield * performance ratio * solar radiation incident

User inputs:

- Module area and Watt peak

Depends on:

- Temperature
- Solar radiation
- Day of the year

Photovoltaic

Solar panel yield is the percentage of:

- Watt peak in kW / module area in m^2

Performance ratio:

- All other losses combined + temperature loss

Temperature loss:

- $L_t = \max((T - 25) * 0.005, 0)$

Photovoltaic

Solar radiation incident:

- Solar panels are mostly tilted
- Solar radiation is tilted based on the day of the year and the latitude of the measurement
- The solar radiation incident describes the effective solar radiation in a tilted surface based on:
  - horizontal sun power in W/m^2
  - Elevation angle alpha
  - Solar panel tilt beta

Photovoltaic

Elevation angle alpha:

- 90 – latitude of panel + delta

Declination angle delta:

- 23.45 * sin(360/365 * (284 * day of the year))

To get the solar radiation incident the following equation can be used:

- Horizontal sunpower * (sin(alpha*beta)/sin(alpha))

Battery

Battery

For the battery we set the interval for charging and discharging to one hour.

The equation given in the slides therefore becomes easier.

The equation in the implementation uses max and min functionalities to ensure the constraints of the battery as defined in the slides hold true.

Demand side

Demand side

For the demand model we implemented 2 different profiles:

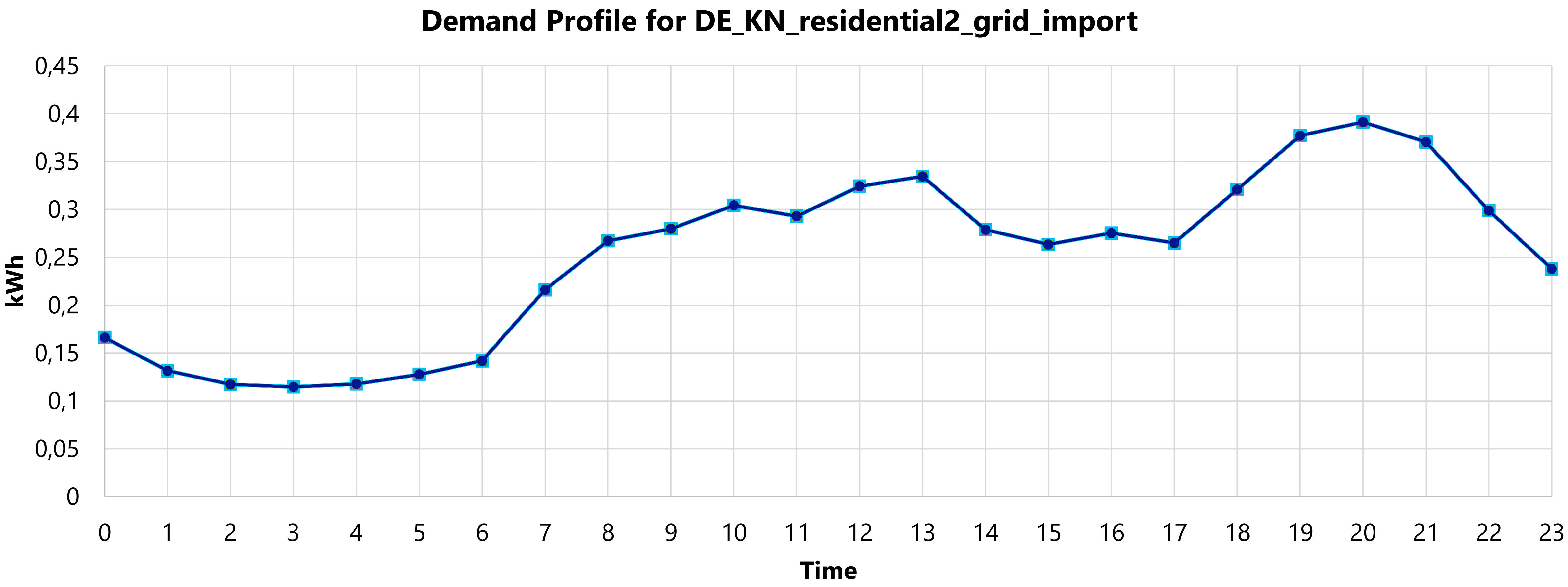
- normal consumers
- commercial consumers

For both we calculated the power demand per m^2 based on the hour of the day.

To get the power demand of a specified consumer type one therefore only must specify the area, the occupation (between 1 and 0) and the hour of the day:

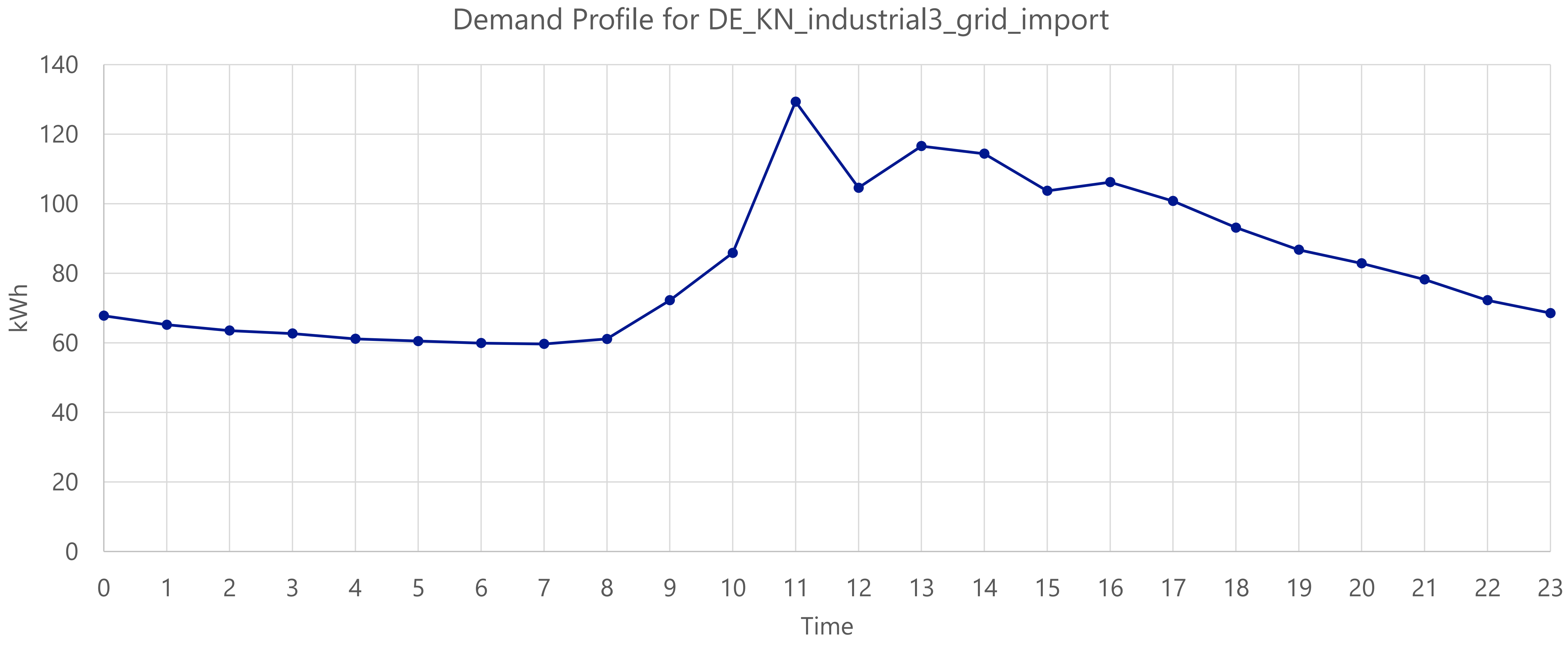
  - Consumption[h] * area * occupation

Home



Demand Profile for DE_KN_residential2_grid_import
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
kWh
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time

Office building



Demo