FLEXe T1.1 Scenarios

Uncertainties in future energy systems that need to be estimated for scenario simulations:

- Costs of technologies and fuels, CO2 prices
- Electricity and heat demand (profile and annual demand)
- Amount of wind and PV and nuclear (can also come from the investment model)
- CHP power-to-heat ratio and role of biomass (also adequacy of biomass)
- Changes in regulation/policy/ design of energy markets

Possible flexibility options that can be considered as scenario variations:

- District heating: heat pumps, heat storages, electric boilers
- Electric heating in buildings: heat storages enabling flexible electricity demand
- Smart charging/discharging of electric vehicles
- Other forms of demand response (peak shaving and time shifting)
- Pumped hydro and possibilities to increase reservoir hydro
- Electricity storages
- Power-to-gas, biogas (and transport energy use)
- Power-to-chemicals
- Transmission (interconnectors between model regions)
- Enhanced flexibility of conventional power plants (minimum load and ramping)

Considering these options, the following scenarios are proposed for FLEXe FP1. The scenarios can be used directly by all WPs in FLEXe, as appropriate, or based on model run outputs from Balmorel/WILMAR, for North European market area (Nordic countries, Germany, Poland, Baltic countries) in Task 1.3.

Basic scenarios proposed:

Starting point, year 2020, for all scenarios: Current ENTSO-E plans for transmission lines are assumed and the model is not allowed to invest in additional transmission lines. Fuel prices are based on the IEA New Policies scenarios. Four nuclear units will be retired in Sweden by 2020. Wind and PV will be approximately according to the EU targets for different countries in 2020 (overall 15% of the consumption in the model footprint). In year 2050 there will no longer be coal allowed in the system.

The target is to model specific amounts of wind power and PV in the scenarios. However, we also want to see at what investment cost levels this would happen. Therefore, the investment cost of wind power and PV will be adjusted so that the resulting shares of wind power and PV are close to the desired levels described here.

Scenario A – low wind/PV, smaller need for flexibility:

- Wind/PV grow moderately (25 % in 2030 and 40 % in 2050).
- In Nordic countries: Some base load remains. After 2020 retirements, rest of the Swedish nuclear fleet will be in use for 60 years (i.e. during 2030 - 2050 time period). In Finland, Loviisa will be retired before 2030 (in principle LO2 would be retired in December 2030). New nuclear investments are allowed in Sweden and Finland based on cost. District heating demand remains stable.
- In Germany and Poland: nuclear will disappear, district heating will grow.

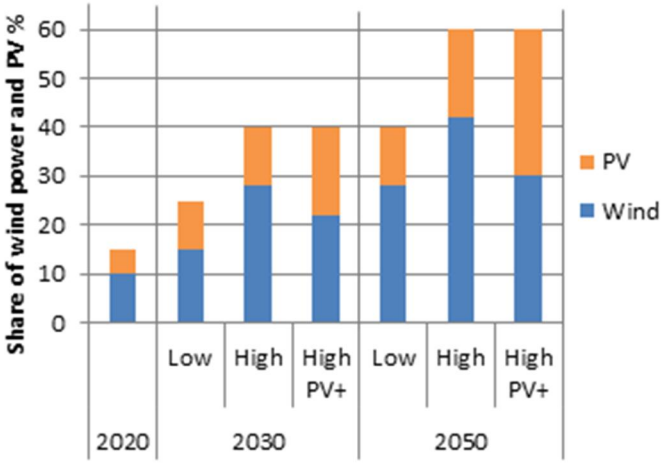
- Electricity demand will increase with BAU trajectory. EVs will appear, but in moderate quantities. Charging of EVs will be uncontrolled. End-user heat pumps and solar heating will grow moderately.

Scenario B – high wind/PV with higher need for flexibility:

- Wind/PV grow strongly. Wind/PV share 40 % in 2030 and 60 % in 2050
- Nordic countries: no new nuclear to Finland after Hanhikivi I. In Sweden rest of nuclear fleet will be retired, district heating demand will decrease (heat pumps and some solar heating). Industrial heat demand stable.
- Germany: nuclear will disappear. District heating will remain stable.
- Electricity consumption will increase EVs will grow, but moderately. End user heat pumps and solar heating will grow strongly especially in sub-urban areas and in countryside.

Scenario C – high wind/PV+ (with increased weight on PV), the largest need for flexibility:

- Wind/PV will grow with PV becaming as prevalent as wind by 2050. Otherwise same as scenario B.



This will mean following simulation runs:

1. Scenario A share of wind/PV in the order of 15 % (2020),25 % (2030) and 40 % (2050) of yearly demand
2. Scenario B share of wind/PV about 40 % (2030) and 60 % (2050) of yearly demand, Swedish nuclear phased out
3. Scenario C share of wind/PV about 40 % (2030) and 60 % with PV dominating, Swedish nuclear phased out (year 2050)

Runs for December 2015 – need for flexibility with a system based on current/state-of-the-art technologies:

The order of priority of the runs with Balmorel and WILMAR (T1.3) is (the cases that are assumed to be the most interesting for others are listed first – the last ones are left out if there is not enough time before the end of 2015):

1. **Scenario A / 2020**
2. **Scenario B / 2030**
3. **Scenario B / 2050**
4. **Scenario C / 2050**
5. Scenario A / 2030
6. Scenario C / 2030
7. Scenario A / 2050 (assumed to be relatively similar to Scenario B / 2030)

If time, these scenarios could be run with selected flexibility options in order to provide market price time series where the impact of flexibility is present for the other project partners.

Runs proposed for Summer 2016 – with inputs from other WPs on future flexibility options:

By summer 2016 we will perform a larger number of scenarios. The main difference is that flexibility options will be enabled (demand response; heat sector; electricity storages; conventional power plant enhanced flexibility and new flexible power plants; Power-to-gas; transmission interconnectors) – one by one or in groups depending on how the modelling progresses.

In addition to the flexibility scenarios where the share of wind and PV are fixed, the share of wind power and PV will set free in order to see the impact of increased flexibility also on the cost optimal share of variable generation. Larger, close to 100% renewables scenarios will be looked at if time/resources allow.

We will also perform some sensitivities regarding fuel prices, electricity and heat demand as well as market design features to the extent they can be captured with the existing models.

Cost assumptions

Technology type	Investment cost (€/kW)
Heat boiler (electric)	60
Heat boiler (electric) + grid	190
Heat storage	4
Heat pump	575
PV	200-1394
Heat boiler (fuel oil)	105
Heat boiler (nat gas)	100
Heat boiler (wood)	400
Gas engine	670
Gas turbine	550
Combined cycle, condensing (nat gas)	1000
Combined cycle, CHP extraction (nat gas)	1300
Steam turbine, condensing (wood)	1700
Steam turbine, CHP extraction (wood)	2000
Steam turbine, CHP extraction, small size (wood)	2800
Nuclear	4800
Wind turbine onshore (cheapest level)	850-1600
Wind turbine onshore (most expensive level)	1050-1900

	Fuel price (€/GJ)		
	2020	2030	2050
COAL	2.7	2.9	-
FUELOIL	14	15	17
LIGHTOIL	20	21	23
LIGNITE	2.2	2.3	-
NAT_GAS	8	9	10
NUCLEAR	1.5	1.5	1.5
PEAT	3.5	3.5	3.5

SHALE	1.5	1.5	1.5
STRAW	4.5	4.5	4.5
WOOD	5	5	5
WOOD_WASTE	2.5	2.5	2.5

- Coal and lignite are not allowed to be used in 2050.

	CO_2 price (€/t)		
	2020	2030	2050
Scenario A	17	29	17?*
Scenario B	17	29	49
Scenario C	17	29	49

* CO_2 price in Scenario A / 2050 needs to be lowered from IEA New Policies assumptions to be able to get only 40 % share of wind+PV without increasing the investment cost of wind power over the 1600 €/kW.