Modelling Renewable Energy Integration Technologies in the EnergyPLAN Tool

This tutorial outlines how you can simulate various renewable energy integration technologies in the EnergyPLAN tool. In this first exercise, we will create a reference scenario, which is used as a starting point for analysing how renewable energy can be integrated into an energy system. Afterwards, this reference scenario will then be changed so it can integrate more intermittent renewable energy.

Based on previous research, approximately 6 key changes are necessary in existing energy systems to transition to renewable energy. In this tutorial the first three of these steps will be modelled and analysed in the EnergyPLAN tool after the reference 'starting point' is created. These are:

1. Regulating conventional power plants by varying their output to accommodate renewables. In other words, when the wind is blowing too much the power plants should shut down, and when the wind is not blowing enough then the power plants should produce more. This will enable a wind penetration up to **25%** of electricity production.
2. Power Plants are converted to Combined Heat and Power which are regulated according to wind production using Thermal Storage and the District Heating network. This will enable a wind penetration up to **25%** of electricity production, but it will be more efficient than in step 1.
3. Heat pumps and thermal storage in buildings and district heating networks. This will enable a wind penetration up to **40%** of electricity production.

This transition is illustrated graphically below. Figure 1 illustrates what today's energy system looks like: it is a very segregated energy system with separate supplies for electricity, heating and transport. This is what the energy system looks like in step 1.

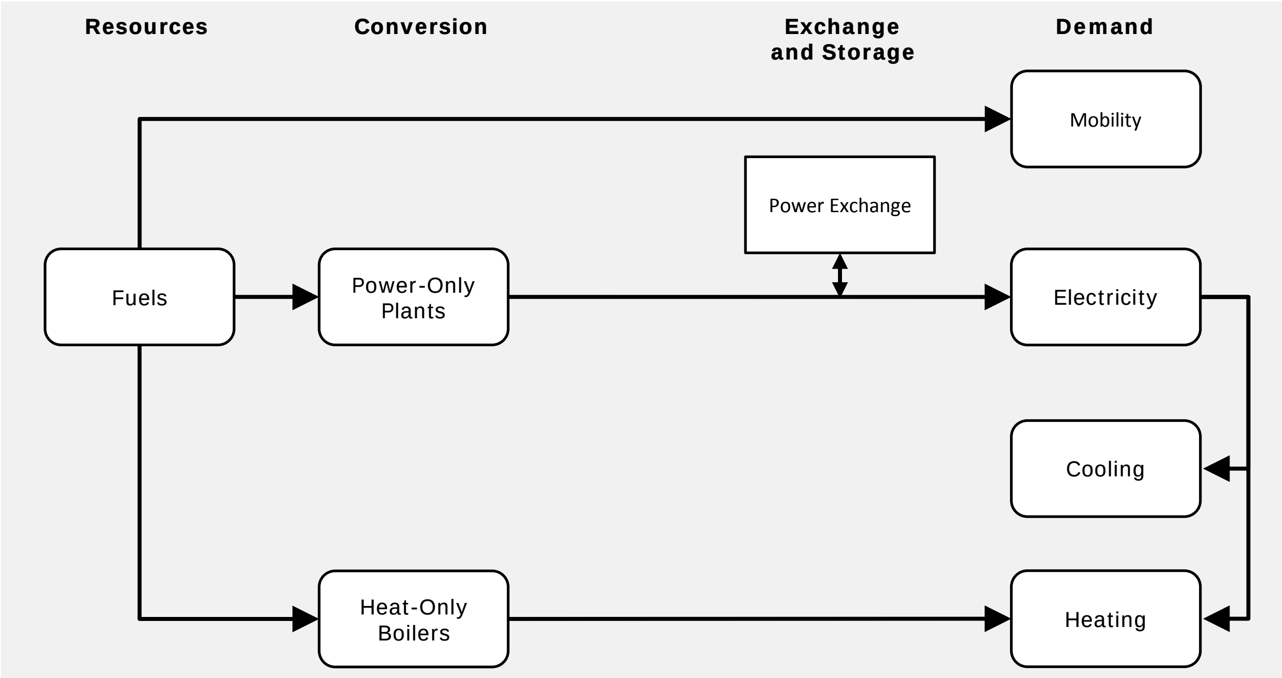

Figure 1: Interaction between sectors and technologies in today's typical energy system.

Figure 2 illustrates a smart energy system, where the electricity, heating, and transport sectors are interconnected with one another. This interconnection creates a lot of flexibility which enables the energy system to become dependent on intermittent renewable energy such as wind and solar. This is what the energy system looks like in step 3 here.

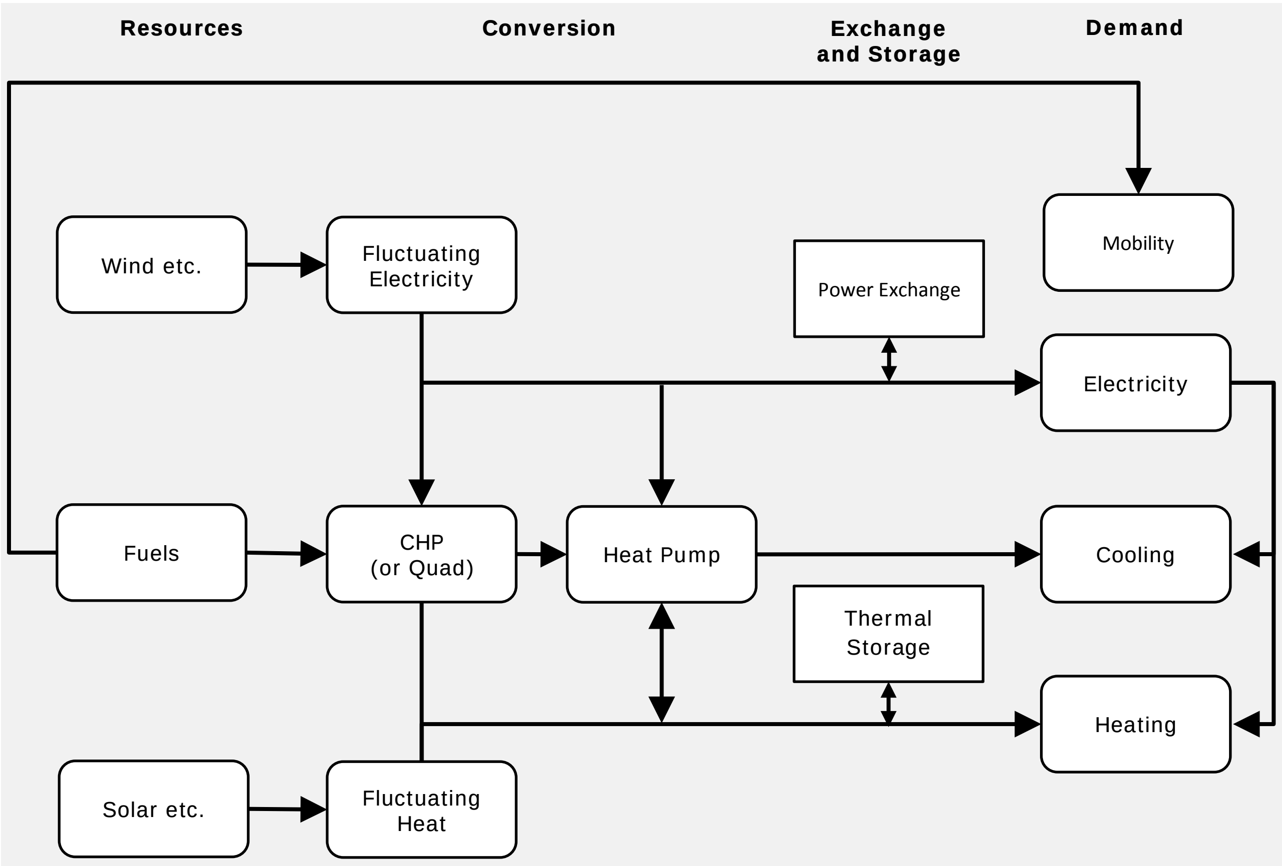

Figure 2: Interaction between sectors and technologies in an energy system with district heating and heat pumps.

Below is an overview of the costs you will need during these exercises.

- You can assume an Interest Rate of 3%

	Unit	Investment (Unit)	Lifetime (years)	Fixed Operation and Maintenance (% of investment)
Exercise A				
Gas Power Plant	M€/MW	0.9	25	2.0
Oil Boiler	€/boiler	6600	20	3.8
Conventional Car	€/vehicle	12000	16	7.7
Truck/Bus	€/vehicle	160000	8	1.2
Exercise B				
Wind Power	M€/MW	1.25	20	3.0
Exercise C				
Small CHP	M€/MWe	1.2	25	3.8
Large CHP	M€/MWe	0.8	25	3.6
Boiler	M€/MWth	0.1	35	3.7
Thermal Storage	M€/GWh	3.0	20	0.7
District Heating Pipes	M€/TWh	72	40	1.3
District Heating Heat Exchangers*	€/exchanger	5500	20	2.7
Exercise D				
Heat Pump	€/heat pump	14000	20	1.0
Centralised Heat Pumps	M€/MWe	3.5	25	2.0

*Includes the branch pipe.

Fuel Costs

(€/GJ)		Coal	Diesel	Petrol/Jet Fuel	Natural Gas
Fuel Price		3	16.5	17.5	10
Fuel Handling Costs	To Central Plant	0	-	-	0.4
	To Decentral Plant	1.5	-	-	2
	To Individual Households	2.5	2	-	3
	To Road Transportation	-	1.9	1.9	2
	To Air Transportation	-	-	0.5	-