# Exercise: Transitioning to a more efficient energy system

The goal of this exercise is to first identify a reference energy system for a city like Beijing. Secondly, the goal is to identify a suitable more efficient energy system for the same system. To determine if your alternative is more efficient you should compare the alternative to the reference system.

A great number of alternatives can be designed, so please consider if you can achieve a better solution.

For presentation I suggest presenting the reference energy system alongside one or two alternatives that you have calculated. Please compare the systems to each other.

To make this easier I have uploaded distribution files and a scenario file you can start in. These are found at [www.energyplan.eu/tsinghua](http://www.energyplan.eu/tsinghua)

Please put them into their respective folder in the EnergyPLAN\energyPLAN data\ folder.

To build the reference energy system use the following data. We will only focus on the electricity and heating sector:

## Electricity and heat demand in “Beijing”

|  |  |
| --- | --- |
| Electricity demand | 94 TWh |
| Heating demand | 130 TWh |

Reference: <https://www.sciencedirect.com/science/article/pii/S0360544219314926>

First step is to make a system for “Beijing” only based on natural gas individual heating and natural gas power plants. Start by putting in the electricity and heat demands.

Data on individual natural gas boilers:

|  |  |
| --- | --- |
| Efficiency | 95% |
| Cost | 3.2 M€/1000 Units |
| Lifetime | 20 years |
| Fixed O&M | 6.5% |

Data on gas power plants:

|  |  |
| --- | --- |
| Efficiency | 55% |
| Cost | 0.9 M€/MW |
| Lifetime | 25 years |
| Fixed O&M | 3.3% |

Input the power capacity of power plants to be the maximum electricity demand +20%.

Save this as your reference system, and document fuel consumption, CO2 and total annual costs.

The task for you is to design one or more alternative scenarios that are more efficient than the reference system for Beijing. You can utilize the number of technologies described below (and follow the links if you want to include other technologies). To compare efficiency, you can look at comparing fuel consumption, fossil fuel consumption, CO2 emissions and costs.

## Renewable energy

You can implement renewable electricity units in form of wind and solar power.

For this exercise we do not assume any geographical restrictions for renewable energy associated with Beijing.

Data for wind turbines

|  |  |
| --- | --- |
| Cost | 1.12 M€/MW |
| Lifetime | 27 years |
| Fixed O&M | 1.3% |

Data for solar power

|  |  |
| --- | --- |
| Cost | 0.62 M€/MW |
| Lifetime | 35 years |
| Fixed O&M | 1.3% |

When inputting renewable energy consider how much you utilize (excess electricity).

## District heating

100 TWh of the 130 TWh heating demand can be converted to district heating. We will use Group 3 to model the district heating system.

The loss in the district heating grid is 10%.

Cost for district heating grid:

|  |  |
| --- | --- |
| Cost | 150 M€/TWh |
| Lifetime | 40 years |
| Fixed O&M | 0% |

The cost for district heating you have to input as an *additional cost.*

The following production units can be chosen for the district heating system

Data on gas combined heat and power (CHP3):

|  |  |
| --- | --- |
| Electric efficiency | 51% |
| Heat efficiency | 30% |
| Cost | 0.9 M€/MW |
| Lifetime | 25 years |
| Fixed O&M | 3.3% |

Natural gas boilers (Boiler3):

|  |  |
| --- | --- |
| Heat efficiency | 98% |
| Cost | 0.06 M€/MW |
| Lifetime | 25 years |
| Fixed O&M | 3.3% |

District heating compression heat pumps:

|  |  |
| --- | --- |
| Heat efficiency (COP) | 3.5 |
| Cost | 2.31 M€/MW |
| Lifetime | 25 years |
| Fixed O&M | 0.5% |

Thermal storages:

|  |  |
| --- | --- |
| Cost | 3 M€/GWh |
| Lifetime | 40 years |
| Fixed O&M | 0.3% |

For electricity and district heating:  
<https://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_el_and_dh.pdf>

For district heating grid:  
<https://ens.dk/sites/ens.dk/files/Analyser/technology_data_for_energy_transport.pdf>

For storages: <https://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_energy_storage.pdf>

## Individual heating technologies

Natural gas boilers:

|  |  |
| --- | --- |
| Efficiency | 95% |
| Cost | 3.2 M€/1000 Units |
| Lifetime | 20 years |
| Fixed O&M | 6.5% |

Electric Heat pumps:

|  |  |
| --- | --- |
| Efficiency (COP) | 3.25 |
| Cost | 10 M€/1000 Units |
| Lifetime | 18 years |
| Fixed O&M | 2.9% |

Electric boilers:

|  |  |
| --- | --- |
| Efficiency | 100% |
| Cost | 3.0 M€/1000 Units |
| Lifetime | 30 years |
| Fixed O&M | 0.8% |

For individual heating technologies: <https://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_individual_heating_installations.pdf>