IEooc_Application4_Exercise4: Energy Demand Scenarios

Sample solution

Goal: *Conduct back-of-the-envelope calculations, estimate energy demand by sector, identify scenario drivers, becoming comfortable with dealing with very large numbers.*

Task: Create an energy demand scenario for a country/region of your choice for 2040! The scenario should be a likely one according to your judgement. Choose a meaningful and feasible scope of your analysis (i.e., which sectors and energy carriers you consider)!

You are free to work in groups if you like! Focus on understanding a few key sectors properly instead of trying to cover all energy usages in an aggregated manner!

Questions:

1) Sectors: Which sectors and devices (in industry, households, etc.) are the major energy consumers and thus determine society's energy demand? From your findings, determine the scope of your scenario exercise (i.e., which sectors/technologies and energy carriers you consider), and which country/region you focus on!

   >> Different sector breakdowns are available. A major distinction that needs to be made is to clarify whether primary energy (from nature into the industrial system) or secondary energy (after conversion is considered. For the first case, the coarsest breakdown is buildings (residential and commercial/services), transport, industry, and electric power generation (split US, 2012: 10/27/21/40 %). Sometimes, industry is further broken down into agriculture/forestry, energy-intensive industry (material production), and light industry (manufacturing).
   https://www.eia.gov/totalenergy/data/monthly/pdf/flow/primary_energy.pdf

   For secondary energy, a coarse breakdown would be by energy carrier (oil, biomass, gas, coal, electricity), by conversion device (combustion engines, electric motors, burners, heaters/heat exchangers, coolers, lighters, and electronic devices), or by end use (motion, heat, cooling, light, sound, and communication/information/data).
   http://dx.doi.org/10.1016/j.energy.2010.01.024

   A third option is to break down the energy by end-use sector, for example, into industry, traffic, households, and commerce/services:
   (https://www.umweltbundesamt.de/daten/energiebereitstellung-verbrauch/energieverbrauch-nach-energietraegern-sektoren).

   >> Scoping: For this sample solution, *Germany* is selected as region of study and the following sectors are considered as (important) examples:

+ *Buildings* (residential only): Heating and cooling demand,
+ *Transport*: energy demand from passenger vehicles, and
+ *Industry*: energy demand for steel making and cement.

2) Demand drivers: What parameters are needed to estimate future energy demand in the sectors you chose?

>> Drivers can be located at different levels of the system. In most scenarios the main drivers are population and affluence, measured as GDP. Sometimes, the urbanisation rate is taken in addition. Another option is to directly model the services needed, like demand for housing services, for transportation, or food production.

For this sample solution a combination of both approaches was chosen. First, the current levels of housing demand (in m^2 per person), passenger vehicle transport (in vehicles and vehicle-km per year), and industry (current cement and steel production levels) were sourced from the internet and scaled with a UN population scenario. (Cf. Excel workbook). Since Germany's population is expected to not change much (https://esa.un.org/unpd/wpp/DataQuery/), it was assumed that the driver population will have no influence compared to lifestyle changes, efficiency gains, and increasing affluence. Specific energy efficiency values and possible future levels were compiled as well from various sources, cf. Excel workbook.

3) What are the main differences when trying to estimate energy demand for let's say 2020 compared to 2040?

>> Short answer: The more remote the future the less certainty there is about what will happen then.
More detailed: The lifetime of in-use stocks, like buildings and vehicles, determines how much the present stock composition influences the energy demand in the future. For example, in 2020, the majority of the vehicle fleet will be cars that are already on the road today. Hence, we already know their specific energy consumption and the potential for changing the fleet composition is limited. In 2040, most currently used vehicles will have reach end-of-life, and a completely new fleet will be there, with new and more efficient technologies deployed at much higher rates compared to what is possible by 2020. Next to the reduced lock-in by current stocks, the more remote future has greater uncertainty regarding lifestyle, resource availability, and technology spectrum.

4) Provide some rough energy demand estimates for selected key sectors in the year 2040 for a country/region of your choice. Break down your estimate into different sectors and energy carriers where possible! Which sector/energy carriers show the highest demand? What are the main parameters/mechanisms to consider when estimating future energy demand?

>> Cf. Excel workbook for details and the table below for a summary. Three main mechanisms need to be considered:

- change/reduction in service demand
- increase in energy conversion efficiency
- change in fuel/energy type used

	Base case (today)	Case 1: Conservative	Case 2: RE option	Unit	
Buildings (Heat)	121	79	99	TWh	**Biofuels**
	0	32	92	TWh	**Electricity**
	482	237	0	TWh	**Gas/Coal**
Passenger vehicles	20	120	42	TWh	**Biofuels**
	0	25	58	TWh	**Electricity**
	379	200	42	TWh	**Gas/Coal**
Steel/ Cement	0	0	23	TWh	**Biofuels**
	35	35	23	TWh	**Electricity**
	140	140	70	TWh	**Gas/Coal**
Total	140	199	164	TWh	**Biofuels**
	35	92	174	TWh	**Electricity**
	1001	577	112	TWh	**Gas/Coal**

For comparison: Germany's total energy consumption in 2015 was 2466 TWh (https://www.umweltbundesamt.de/daten/energiebereitstellung-verbrauch/energieverbrauch-nach-energietraegern-sektoren).

In the conservative scenario, buildings and passenger vehicles show similar energy demand, and gas/coal still would be the largest energy carrier. In the advanced scenario with more potentially renewable energy carriers, biofuels and electricity dominate.

For additional information, see

World Energy Outlook:

http://www.iea.org/publications/freepublications/publication/world-energy-outlook-2015.html

Current and future population:

https://esa.un.org/unpd/wpp/DataQuery/