In a bid to help manage the energy transition, one of the nation’s leading energy firms has asked you to create a model that’s able to evaluate plausible dynamics of this energy transition up to 90 years from now. Our lead modeler has already decided that we will use a relatively simple stock and flow chain to represent the energy production infrastructure, and couple it to a learning curve to see how the marginal costs of both conventional and renewable energy change over time.

One of our colleagues has already made a start by completing the model structure governing the conventional energy (T1), and now it is up to you to complete the remaining structure. Note that there are some shadow variables in the model which you may find useful in **Expansion 2**.

**Expansion 1:**

Even though T1 refers to old technologies such as gas fired power plants, these technologies do in fact keep on descending on their learning curves. First, let’s add a learning curve formulation for T1: The *cumulative experience T1* increases through the flow *installation experience T1* and initially is equal to *initial experience T1* which is 10e6 MW. The *installation experience T1* of course amounts to the *commissioning of T1* flow.The *effect of experience on cost T1* is equal to the *cumulative experience T1* divided by *initial experience T1*, raised to the power of *learning curve strength T1*. This *learning curve strength T1* is given by *ln(1-cost reduction per doubling T1)/ln(2)*, where the *cost reduction per doubling T1* equals 10% (i.e., 0.1). The *marginal cost of adding T1* is then simply the product of *initial marginal cost T1* and the *effect of experience on cost T1*, with *initial marginal cost T1* equal to 1e6 EUR/MW.

**Expansion 2:**

Now we will have to add renewable technologies to the model, which we will call T2. This structure should be practically the same as what we have for T1 right now, with a few changes:

* Installed capacity T2 is equal to 3 MW initially
* The initial experience is 10 MW
* The capacity under construction T2 is 1 MW initially
* The planned capacity T2 is initially 0 MW.
* The cost reduction per doubling T2 is 20%
* The initial marginal cost T2 is 8e6 EUR/MW

Change the *desired fraction of new capacity T1* to be equal to (1-*desired fraction of new capacity T2*).

The *desired fraction of new capacity T2* is equal to:

1

𝑚𝑎𝑟𝑔𝑖𝑛𝑎𝑙

𝑐𝑜𝑠𝑡

𝑛𝑒𝑤

𝑐𝑎𝑝𝑎𝑐𝑖𝑡𝑦

𝑇

2

1

+

1

 𝑚𝑎𝑟𝑔𝑖𝑛𝑎𝑙 𝑐𝑜𝑠𝑡 𝑛𝑒𝑤 𝑐𝑎𝑝𝑎𝑐𝑖𝑡𝑦 𝑇1 𝑚𝑎𝑟𝑔𝑖𝑛𝑎𝑙 𝑐𝑜𝑠𝑡 𝑛𝑒𝑤 𝑐𝑎𝑝𝑎𝑐𝑖𝑡𝑦 𝑇2

Don’t forget to modify *new capacity to be installed*. Also add the following two variables: *total installed capacity* and *sustainable energy fraction*.

1. Create the model
2. Simulate the model and provide graphs of the marginal costs of both technologies and the sustainable energy fraction.
3. Explain the observed behaviour
4. There is uncertainty regarding the learning curve parameter of T2. Vary it and draw conclusions.
5. Right now the demand curve is linear. Change it to the following: 15000MW at t0, 22000MW at t10, 19500MW at t20, 25000 MW at t30, 27000MW at t40, 34000MW at t50, 30000MW at t60, 40000MW at t70, 46000MW at t80 and 45000MW at t90. How does the sustainable energy fraction change?