Policy resistance, limits to growth and pulling factors: a system dynamics view of the energy transition explained through a causal loop diagram

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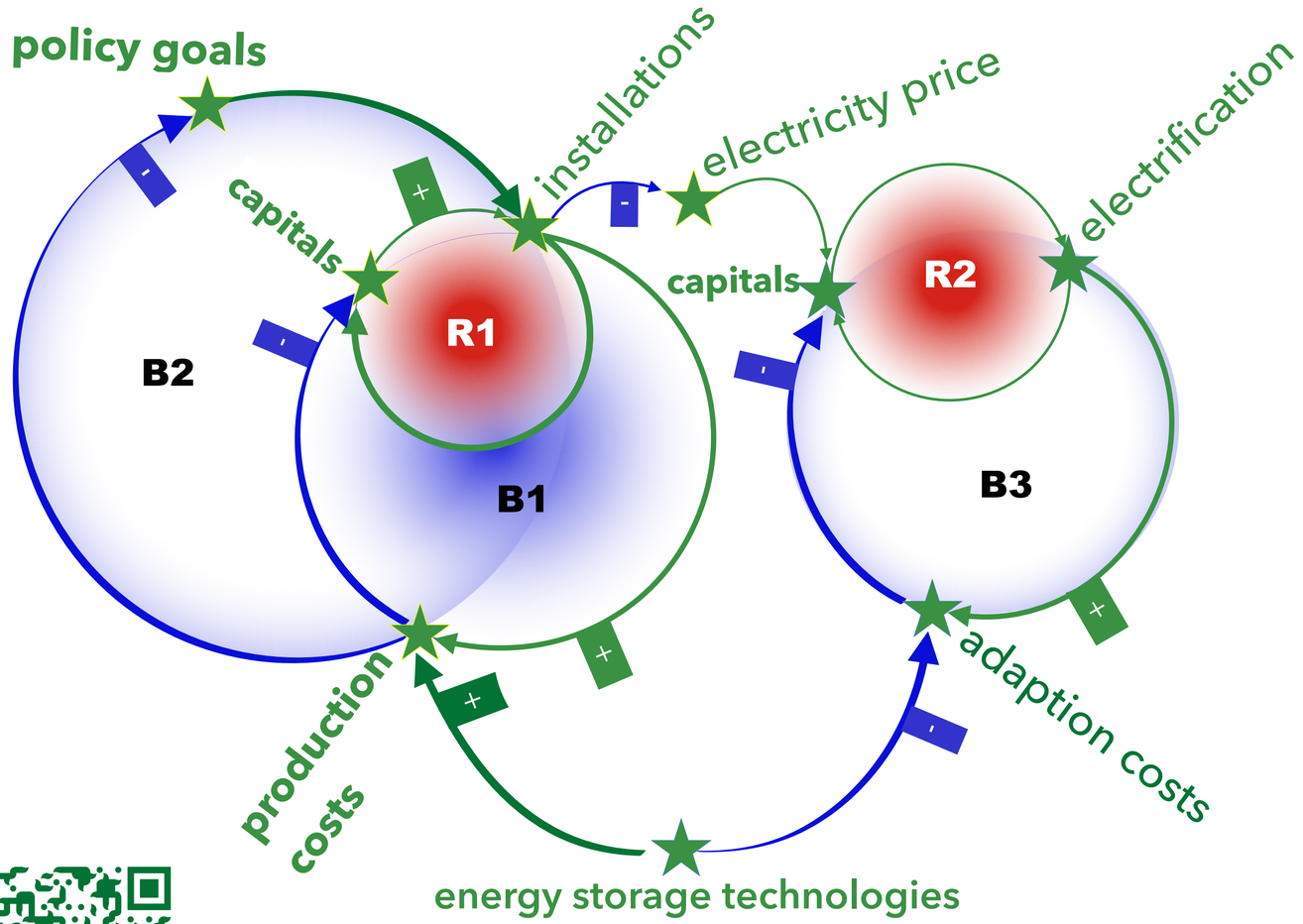


Numerically operable energy transition causal-logic model using system dynamics syntax (NUMEN-LOG)

Purpose: To explain phenomena observed by IEA and other international energy organisations.
Syntax: exponential growth explained by reinforcing loops (**R**) braking/stopping signals explained by balancing loops (**B**); information links:

- →+ the greater/less the cause the greater/less the effect (same)
- → − the greater/less the cause the less/greater the effect (opposite)
- ★ variables in the simplified view

Synthetic representation: the diagram is a simplified view of the model. The following illustrates a sample of richer dynamics included in the current model (see details in QR code page).

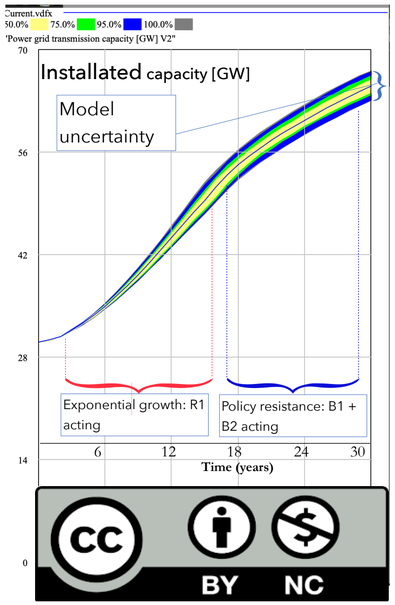
Fast growth (R1) policy measures boost the growth of renewable energy installations →+ learning curve forward →+ bankability of projects →+ new installations

Adaptions costs and policy resistance (B1, B2) number of installation and infrastructures →+ costs of adapting and expanding power grids, skilled labor, and permitting issues →− availability of capital for transition (B1) →− while also eroding policy measures (B2)

New uses growth (R2) Renewables deeply have a strong impact →+ on the price of electricity and stimulate investments that lead to widespread →+ electrification of the energy system.

Costs of phasing out of fossil fuels (B3) energy distribution and use systems will come at the cost of disposing existing infrastructures and technologies affecting negatively →− growth of capitals, skilled workforce, and other resources.
Energy storage is seen as a production cost alleviating adaption costs of use systems.

Example: numerical application: Italy (2020-2050)



Final note. Important in the realisation of the model was the interview of sector experts. The use of the causal diagram was essential for the construction of a (not always shared) narrative.