IEooc_Background2_Exercise1: System-wide effects of renewable energy deployment

Sample Solution

Goal: *Apply systems thinking to renewable energy technologies; read a scientific review.*

In its latest assessment report, the Intergovernmental Panel on Climate Change (IPCC) reviews the state of the art of the science on climate change (working group I), climate change costs and adaptation (working group II), and climate change mitigation (working group III).

With a share of about 35% of total anthropogenic GHG emissions, the energy sector is the largest man-made GHG emitter and thus receives special attention in the assessment report (Bashmakov et al., 2014).

Renewable energy (RE) technologies are a key contributor to reducing GHG emissions in the energy sector.

Reading: IPCC 5TH Assessment Report, Working Group III (Climate Change Mitigation), chapter 7 (Energy Systems) (Bashmakov et al., 2014), provided on the course home page.

The following questions are to be answered (bullet points are sufficient, with reference to the corresponding subsection in the IPCC report)

1) **What types of renewable energy are included in the IPCC 5AR?**
   >> Bioenergy, direct solar energy, geothermal energy, hydropower, ocean energy, and wind energy (7.4.2)

2) **What are the main reasons for the projected large scale deployment of RE, compared to the other low-carbon technologies CCS and nuclear energy?**
   >> Substantial reductions in carbon emissions, mature technologies, increasing economic competitiveness, decentral supply is easy, co-benefits, large risks of nuclear technology and CCS (executive summary). Large supply potential (7.4.2.).

3) **What are the main barriers and concerns regarding renewable energy deployment and how are these barriers addressed?**
   >> Costs, intermittency, public acceptance, environmental concerns, infrastructure requirements, competition for land, concerns about carbon footprint and indirect effects (biomass), material requirements (7.4.2) Dependency on policy instruments such as feed-in tariffs (Executive summary)

4) **What system linkages determine the deployment of RE and thus their future contribution to climate change mitigation, and how would you exploit or address these system linkages?**
Example: In section 7.5.3 it is mentioned, that "the ultimate contribution of RE to overall energy supply may be dictated in part by the future electrification of transportation and heating / cooling or by using RE to produce other energy carriers, e. g., hydrogen". Hence the success of RE depends in part on developments in other parts of the industrial system. I would enlarge the system boundary to not only study the RE technologies themselves but include energy storage and the use of energy (electric vehicles, heat pumps) in my assessments.

>> Several of the main barriers listed under question 3 are related to system linkages:
Intermittency can be addressed with research and policy development on storage and load management.
Public acceptance can be addressed with honest information, education, and sufficiency strategies.
Indirect land use change (7.9.4) can be addressed with certification and conservation policies.
The link between RE and employment, energy security, rural development (7.9.1), and health (7.9.2, Fig. 7.8) can be used to promote renewable energy deployment.

Emissions of particulate matter from fossil fuel combustion are causing 3.2 million premature deaths per year (7.9.2), and "reducing fossil fuel combustion, especially coal combustion, can reduce many forms of pollution and may thus yield co-benefits for health and ecosystems."

RE technologies are more material-intensive than conventional technologies (7.9.2). Increased demand for bulk materials (steel, cement, aluminium) increases life cycle emissions and the use of critical materials may limit the deployment potential if the latter are subject to supply limitations. Research and development on material efficiency (using less material for the same service) or material substitution helps to reduce the environmental footprint and critical material demand of RE technologies.

Reference:

Bashmakov, I., Bruckner, T., Mulugetta, Y., Chum, H., Navarro, A.D.L. V, Edmonds, J. a., Faaij, A., Fungtammasan, B., Garg, A., Hertwich, E.G., Honnery, D., Infield, D., Kainuma, M., Khennas, S., Kim, S., Nimir, H.B., Riahi, K., Strachan, N., Wiser, R., Zhang, X., 2014. Energy systems. In Working Group III contribution to the IPCC 5th Assessment Report "Climate Change 2014: Mitigation of Climate Change", edited by O. Edenhofer, et al. Intergovernmental panel on climate change (IPCC), Genevea.