Assessment of environmental and macro-economic impacts of renewable energy uptake in Oman: A system dynamics approach

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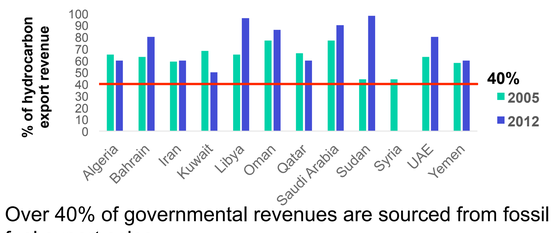
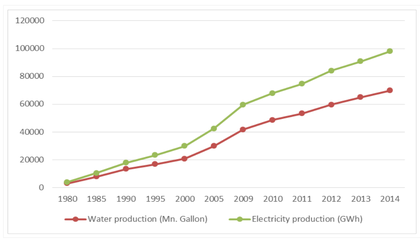
WHY DOES THIS MATTER?

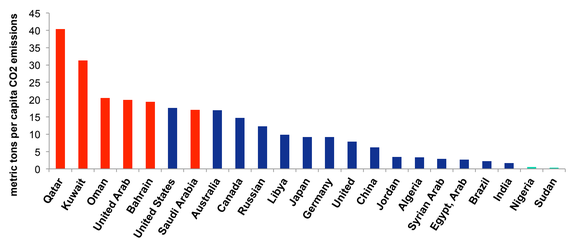
Gulf Cooperation Council (GCC) region is blessed with nearly a third of world oil and more than fifth of global natural gas reserves. Despite the high potential of renewable energy resources in the region, they remain underutilised. Oman is used as a case study in this research **(Figure 1)**.



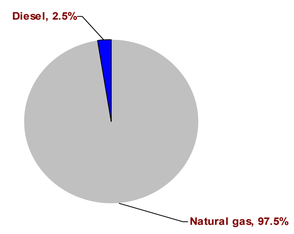
Over 40% of governmental revenues are sourced from fossil fuel export sales.



Growth in electricity and water production in Oman between 1980 and 2014.



Gulf countries (red) showing the highest per capita carbon emission.



Fuel mix in electricity and water generation in Oman (2011).

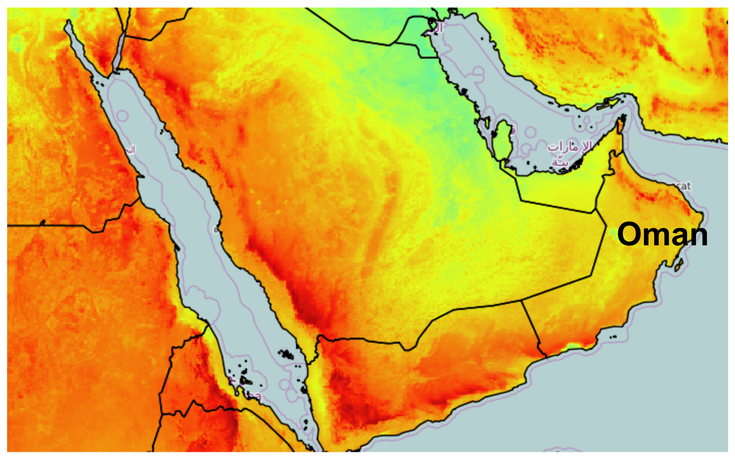


FIGURE 1. Location of Oman in the GCC region. Map shows Yearly Global Horizontal Irradiation for the year 2005 in kWh/m² (source: www.irena.org/GlobalAtlas)

RESEARCH OBJECTIVE: To assess the environmental and macro-economic impacts of renewable energy deployment in Oman through to 2050.

METHODS

PHASE I: Semi-structured interviews were conducted to identify drivers to renewable energy uptake in Oman (**Figure 2**)

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PHASE II: System dynamics methodology was used to build and simulate the interaction between RE domain and economic, social, and environmental domains (**Figure 3**). Four scenarios were evaluated against identified drivers: energy security (**Figure 5 & Table 2**), CO_2 emissions (**Figure 4 & Table 1**) and job creation (**Figure 6**).

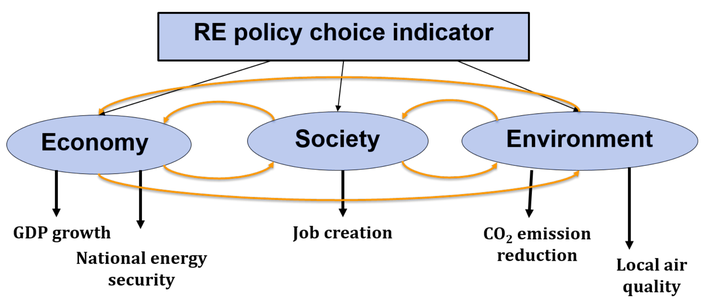

FIGURE 2. Conceptual framework detailing indicators for renewable energy uptake in Oman.

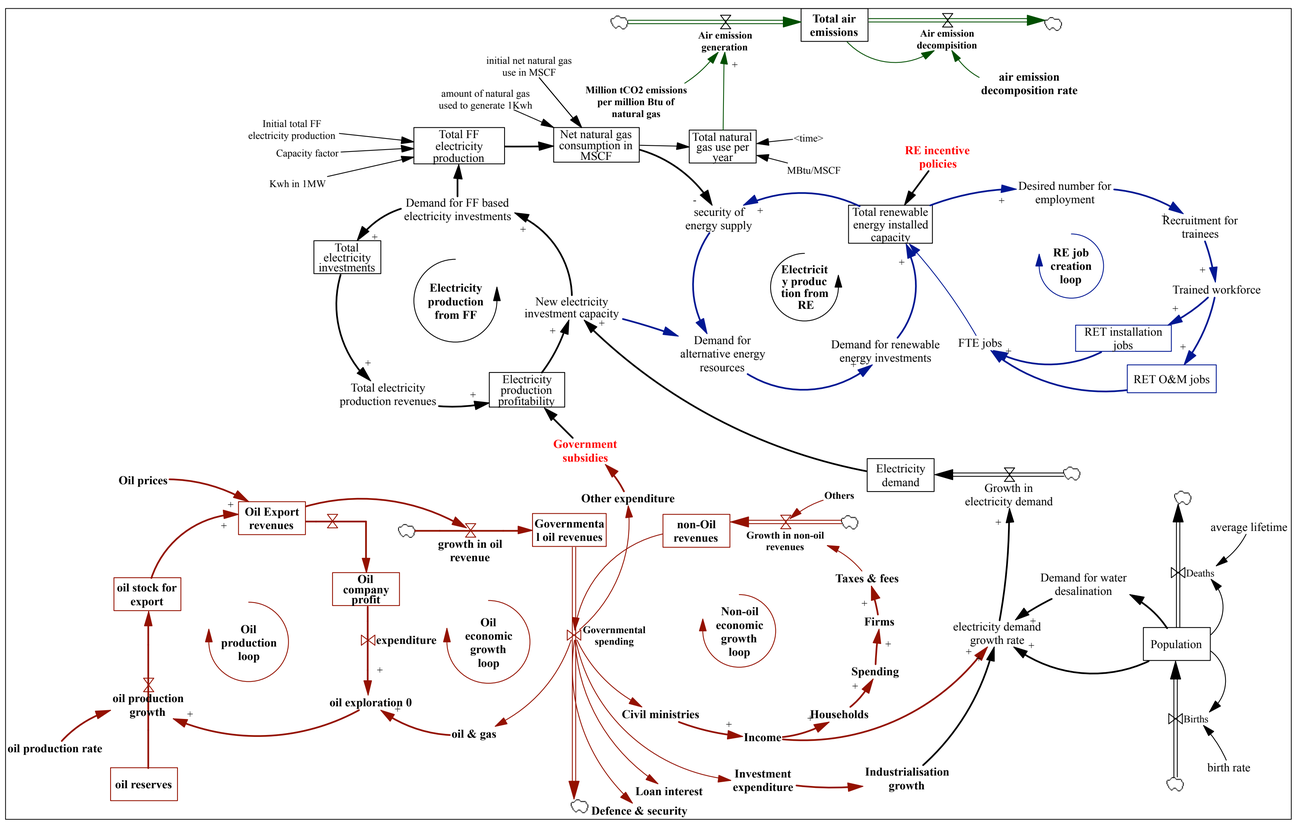

FIGURE 3. Integrated causal loop diagram that accounts for the interlink between RE development (blue) and economic (red), social (blue) and environmental domains (green).

CONCLUSIONS

1. Energy security; changes in oil prices, development of non-oil revenues, growth in electricity demand, growth in CO_2 emissions; and the desire for job creation are main drivers to RE in Oman.
2. Over 1,000 FTE jobs can be created by 2050 in Oman from RE deployment.
3. Natural gas consumption can decline by over 40% through to 2050 due to development of RE in power generation.
4. If no renewables are considered in the future energy mix, the total CO_2 emissions are expected to rise to 2.01 million metric tons in 2050 compared with 0.01 million metric tons in 2015.

KEY RESULTS

Scenario	2020	2030	2040	2050
Moderate	-12%	-23%	-25%	-25%
Advanced	-7%	-32%	-41%	-45%
Ambitious	-9%	-45%	-58%	-63%

TABLE 1. Percentage of CO_2 emission reduction by scenario compared to BAU scenario.

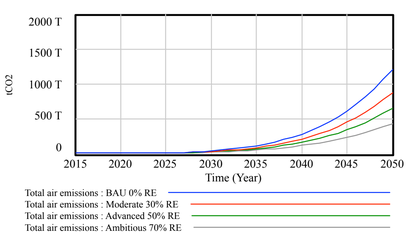

FIGURE 4. Projection of Total CO_2 emissions in million metric tons sourced from power generation under four scenarios through to 2050.

Scenario	2020	2030	2040	2050
Moderate	-10%	-24%	-27%	-29%
Advanced	-17%	-40%	-46%	-48%
Ambitious	-24%	-56%	-64%	-67%

TABLE 2. Average reduction of natural gas use in power generation under different scenarios.

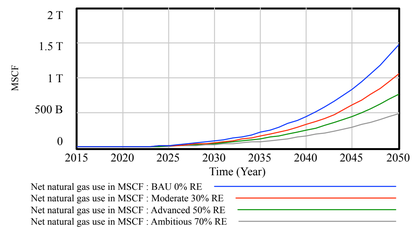

FIGURE 5. Projection of natural gas use in power generation under four scenarios through to 2050.

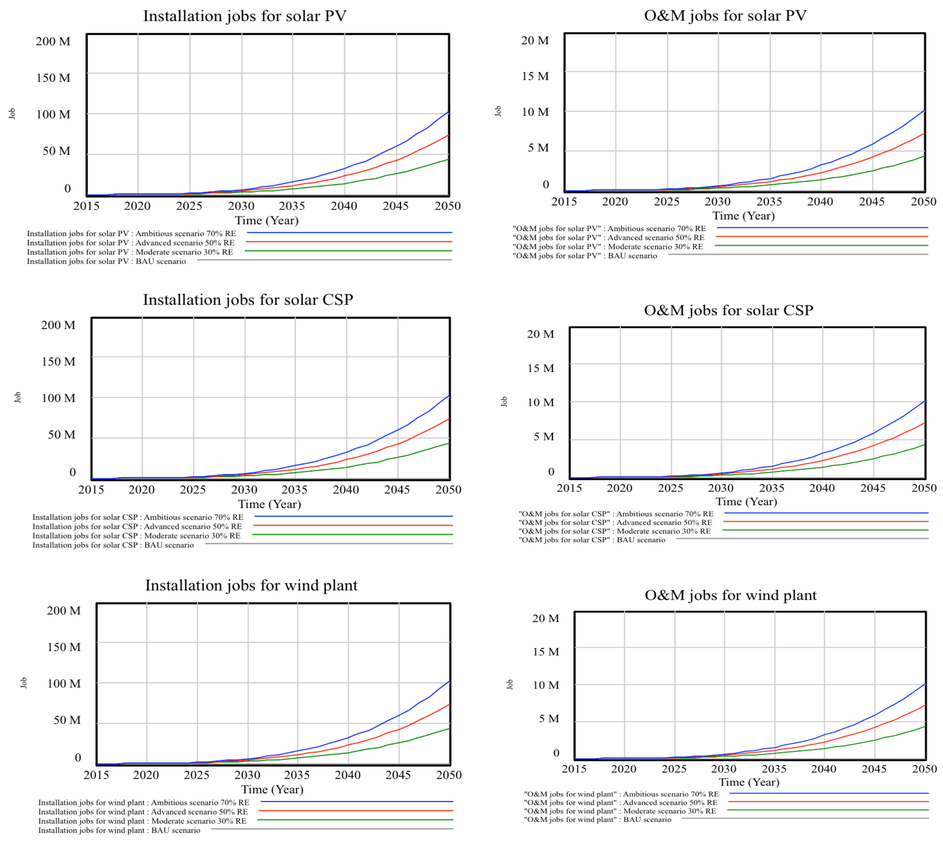

FIGURE 6. Total number of installation and O&M jobs per year created by each type of renewable energy techynology through to 2050.

AKCNOWLEDGEMENTS

I would like to express my gratitude to Dr. Adam Hawkes for his support to kick off the modelling process. Also, thanks to Dr. Marcello Contestabile for his input and guidance on how to integrate the causal loop diagrams with the stock-and-flow models. Also many thanks to Rembrandt koppelaar for sparing me the time to review and make input to economic and social sub-models. Also, thanks to my supervisor Dr. Judith A. Cherni.

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