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LCA comparison between PV and fossil energy production systems

Workshop on Life Cycle Assessment and GIS Tools for Energy planning (TW3-TW4)

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Research Problem: contribution to Sustainability

PV systems are manufactured using fossil fuel intensive materials and processes consuming significant energy amounts during its various life stages. They ought to be assessed on a life cycle basis in order to avoid any error of assessment, especially from a climate change perspective and in order to maintain the best environmental performance. A photovoltaic system is more sustainable only if the energy produced during its operating life compensates the total energy costs that can be estimated through the life cycle assessment (LCA) methodology.

Case Study:

Comparing the impact of the current Lebanese electricity system with electricity production from PV

COMPARING THE IMPACT OF THE CURRENT LEBANESE ELECTRICITY SYSTEM WITH PRODUCTION OF ELECTRICITY FROM PV

COMPARING FOUR SCENARIOS

- 1.8 kWp monocrystalline Photovoltaic (PV) system
- with and without Lead-Acid batteries (PbA)

- existing centralized electricity production mix
- with and without decentralized diesel gensets

(AFP)

COMPARING THE IMPACT OF THE CURRENT LEBANESE ELECTRICITY SYSTEM WITH PRODUCTION OF ELECTRICITY FROM PV

(The Daily Star)

Lebanon's electricity is primarily generated from oil-fired power plants (91.88%) in addition to a small portion from hydropower (8.12%). The suppressed demand is met by the use of decentralized diesel generators at the neighborhood level, constituting a 37% of the total electricity generation.

The functional unit was selected to be 1 kWh of electricity generated and delivered to the Lebanese consumer.

COMPARING THE IMPACT OF THE CURRENT LEBANESE ELECTRICITY SYSTEM WITH PRODUCTION OF ELECTRICITY FROM PV

It is installed on the roof of a public school in the South of Lebanon, as part of the UNDP-CEDRO project that aims to complement the national power sector reform strategy by installing energy efficiency and RE applications in public facilities. The system consists of 24 modules in total, with dimensions of 119.5 cm 54.1 cm 3 cm per module.

LCA METHOD

- **LCA:** Identifying energy and materials used and waste released into the environment over the entire life cycle of the process or activity, including extraction of raw materials, manufacture, transport, distribution, use, reuse, recycling and final disposal.
- **Steps:** 1) Goal and Scope definition; 2) inventory analysis; 3) impact assessment; and 40 Interpretation o results.
- **Indicators :**
  1. energy pay-back period
  2. global warming potential
  3. cumulative energy demand
  4. gross energy requirement
  5. carbon dioxide payback time
  6. net energy ratio
- **Software:** SimaPro
- **Data source**: Ecoinvent 2.2 database

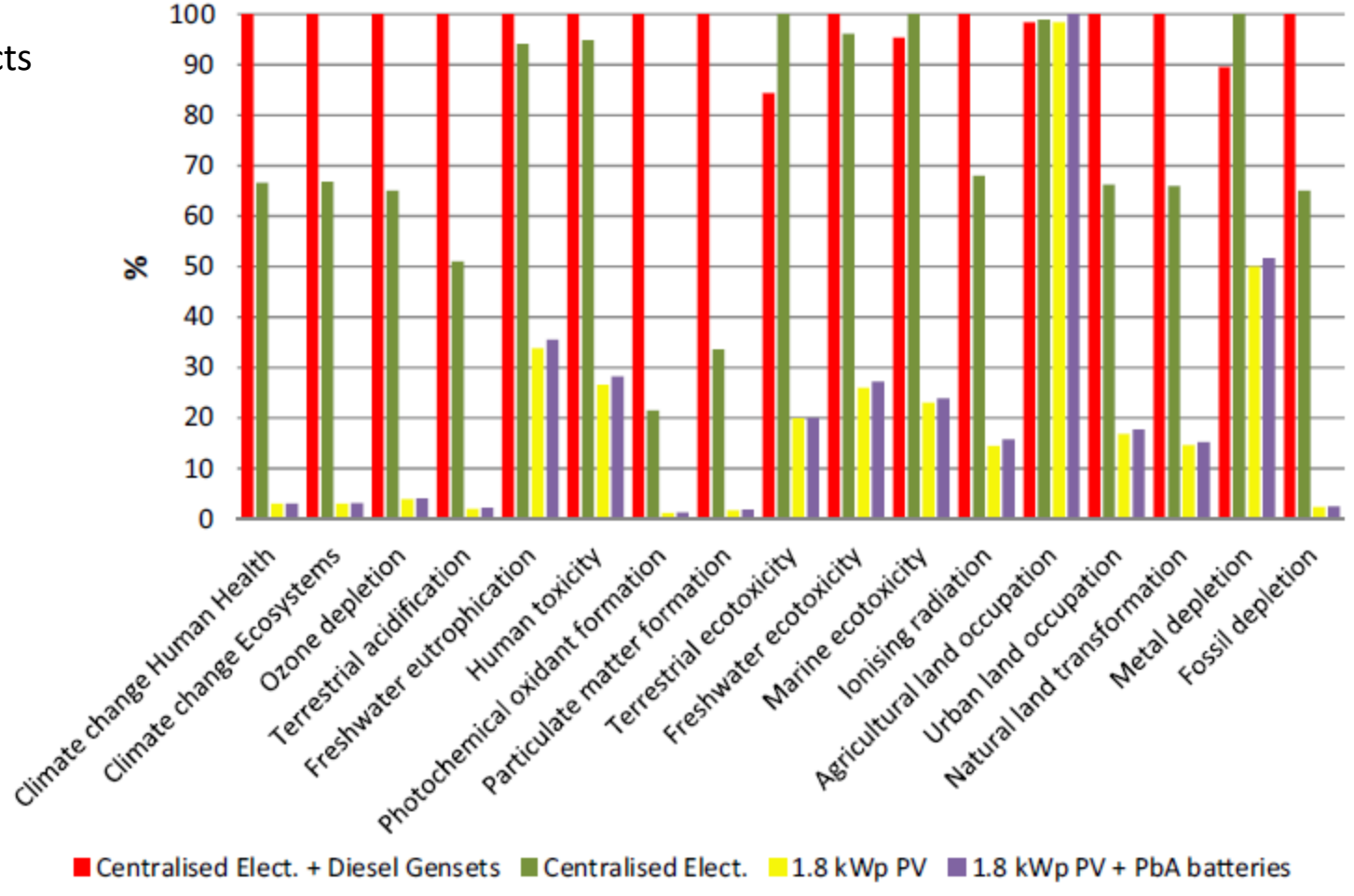
MAIN RESULTS

- LCA has shown that the PV system, even when equipped with batteries, would reduce the environmental burden per delivered output compared to the current Lebanese electricity mix.

- The reduction is even more apparent when decentralized diesel gensets are taken into account.

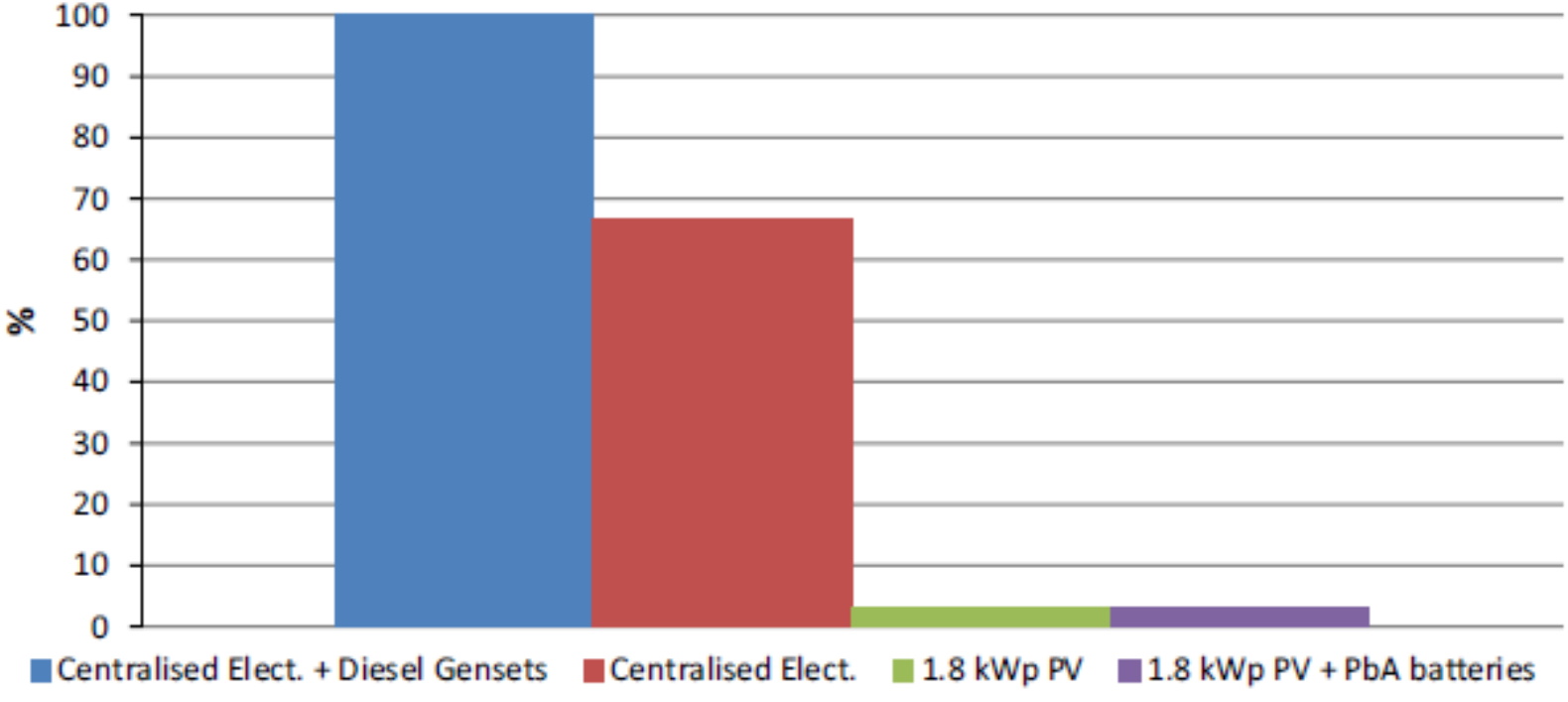
- The results using the ReCiPe impact assessment method's categories indicate reduced impacts for Human Health, Ecosystems and Resources categories in the order of 87%, 95% and 96% respectively when compared to the centralized electricity mix with diesel gensets, and 82%, 92%, 94% respectively when compared to the centralized electricity mix without diesel gensets.

Characterized impacts



CO2 footprint

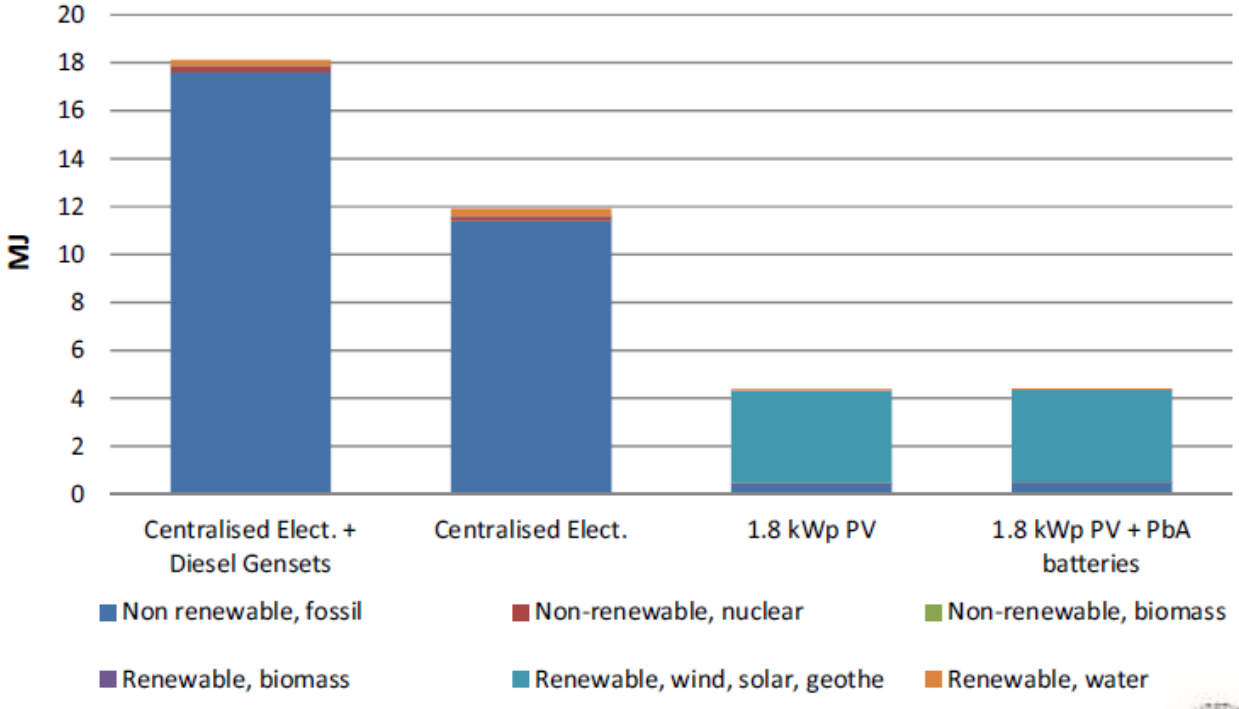
When exploring the carbon footprint of the four electricity generation categories, the footprint of 1 kWh electricity produced from centralised + diesel gensets is 1.23 kg CO2eq/kW h, while the footprint of the centralised generation is 0.818 kg CO2eq/kW h. The photovoltaic generation with and without batteries are 0.0402 kg CO2eq/kW h and 0.0389 kg CO2eq/kW h respectively.



Energy Demand

The cumulative energy demand, used in renewable energy technology research quantifies all the energy consumed during the life cycle of a product.

Total cumulative energy demand for the Lebanese electricity mix with and without diesel gensets per functional unit (1 kW h) is 18.13 MJ and 11.91 MJ respectively, while for the electricity generated by the PV system is 4.41 MJ and 4.39 MJ with and without batteries respectively.



CONCLUSION

- Following the LCA methodology, the results show that the PV systems can help produce a low carbon and reliable electricity supply for Lebanon. Even with inclusion of batteries, the impacts remain far below the current alternatives.

- Trials targeted towards larger commercial and industrial PV applications are ongoing whereby expensive battery storage is replaced by a design to synchronize the PV systems to the existing diesel gensets when power from the utility is off, and to the national grid when power is on. Future PV LCA work should consider these systems in terms of their environmental merits.

- This study can be used for comparative analysis in various countries in the region such as Jordan, Syria and Palestine having similar profiles in terms of per-capita electricity consumption and similar levels of economic development.

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THANK YOU

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Reference:
Kabakian, V., Mcmanus, M., & Harajli, H. (2015). Attributional life cycle assessment of mounted 1.8kWp monocrystalline photovoltaic system with batteries and comparison with fossil energy production system. *Applied Energy,154*, 428-437.