Thermoelectric generation as a part of the optimal solution in off-grid hybrid renewable system in places with low irradiation

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Objectives

- Optimise the system to supply electricity in off-grid locations , minimizing the total cost during the system lifetime
- Demonstrate the economic viability of including TEG (in a cook or heat stove) in the optimal system

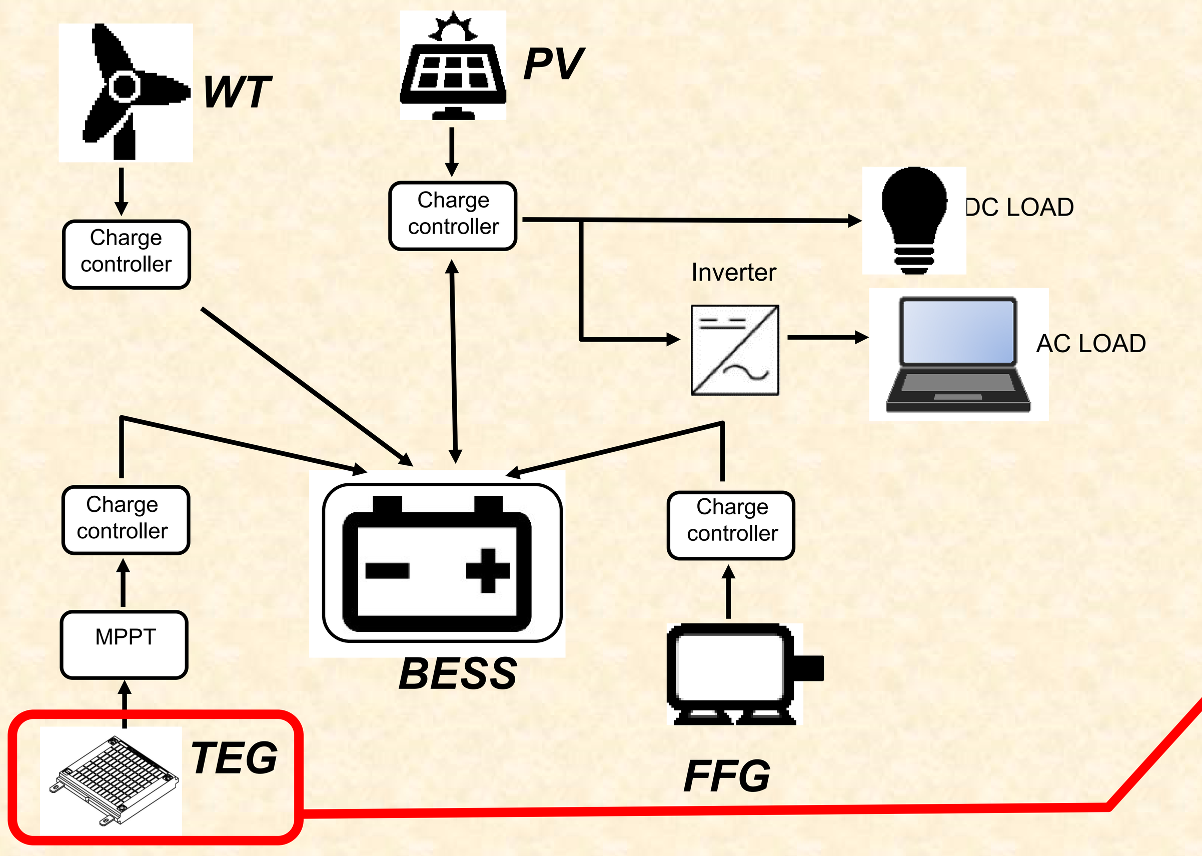
Off-grid hybrid system electrical supply optimization

Electrical load: AC or DC load can be considered

Components: the system can include the following components:

- Photovoltaic generator (PV)
- Wind turbines (WT)
- Fossil Fuel Generator (FFG) (diesel or gasoline usually)
- Battery Energy Storage System (BESS)
- Thermoelectric generator (TEG) into cook or heat stove
- Auxliary components: Inverter and charge controllers

Simulation and optimization: ***iHOGA software*** **(https://ihoga.unizar.es/en/)**



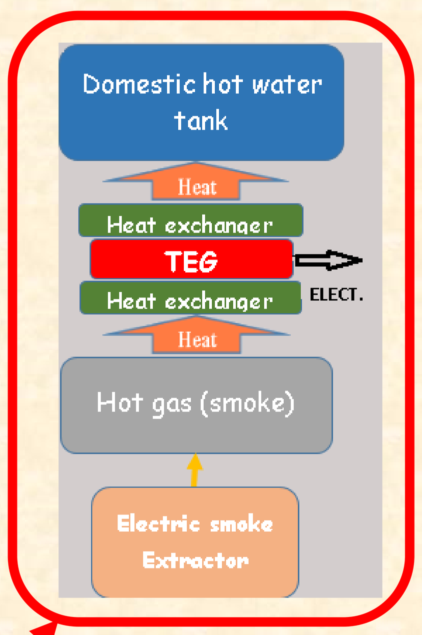


Fig.2 TEG model

Fig.1 Possible components of the hybrid system

Model

- Inputs:
  - Electrical load
  - Meteorological data (irradiation, wind speed, temperature)
  - Operation of the cook or heat stove
  - Components to be considered in the optimization (size, number, parametres)
- TEG model uses standard simplified model including temperature dependance of Seebeck coefficient, electrical conductivity and thermal conductivity
- Each combination of components is simulated in time steps that can be between 1 minute and 1 hour. The simulation is performed during several years, until the end of the battery lifetime is reached. The rest of the years of the system lifetime (usually 20-25 years) the performance is repeated
- Net Present Cost (NPC) is calculated adding all the present costs during the system lifetime, including acquisition, reposition, operation and maintenance costs of all the components.
- The optimal system is the one that can supply the load with minimum NPC.

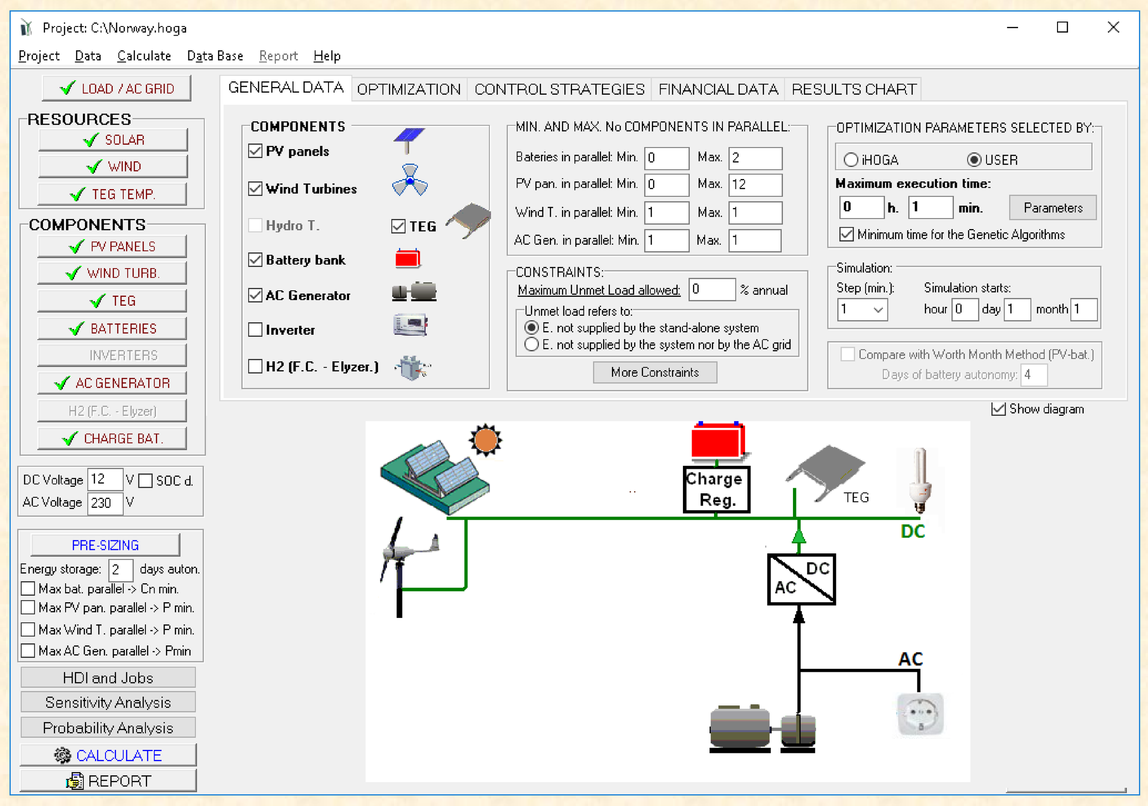


Fig. 3. iHOGA software (https://ihoga.unizar.es/en/)

Validation

- TEG simulation performance has been compared to experimental results of a multifunction stove
- Standard simplified model with temperature dependance combined with the TEM manufacturer matched load output power curves lead to good results

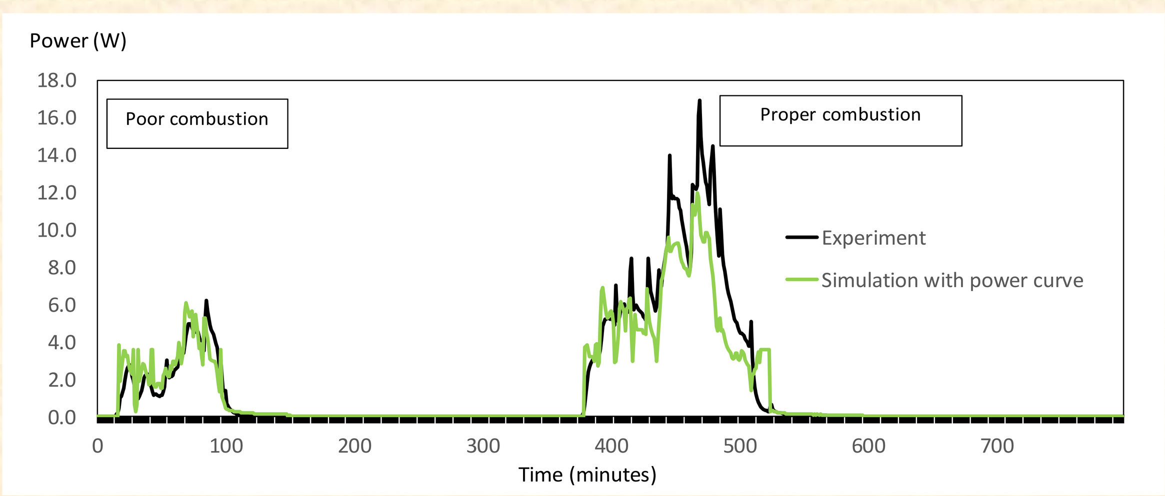


Fig. 4. Validation of the TEG simulation

Results

- The model has been applied in the optimization of the electricity supply of a off-grid household in the south of Norway with heating pellet stove.
- The optimal system is a PV-TEG-FFG-BESS system
- TEG contributes to enlarge the battery lifetime and reduce the fuel consumption of the FFG.

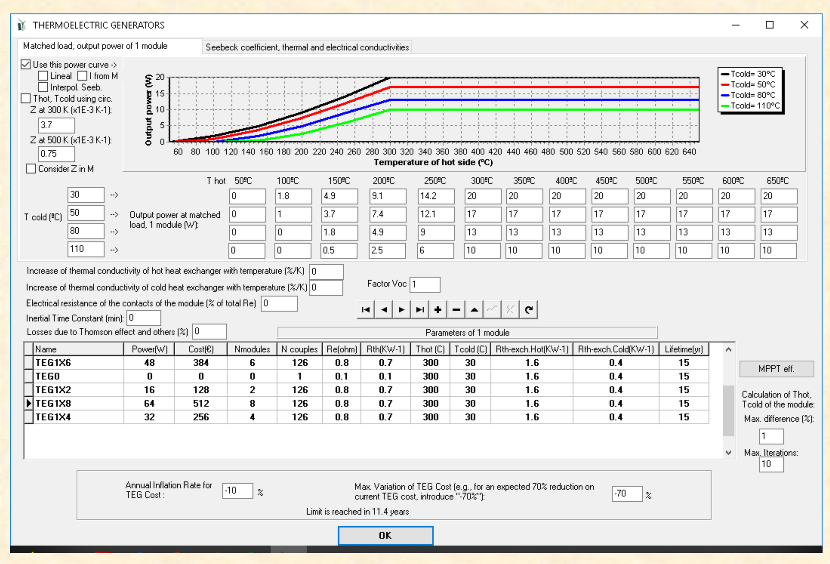


Fig. 5. iHOGA window of the TEG considered in the optimization

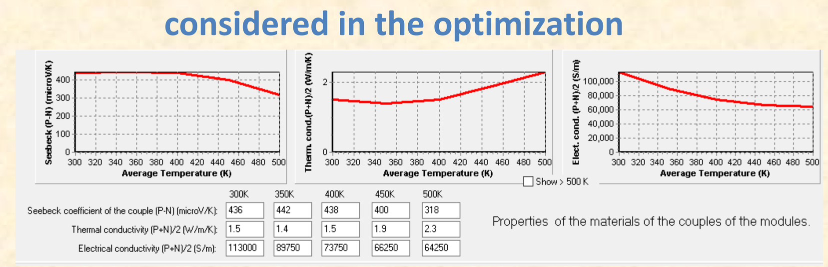


Fig. 6. TEG temperature dependance in iHOGA

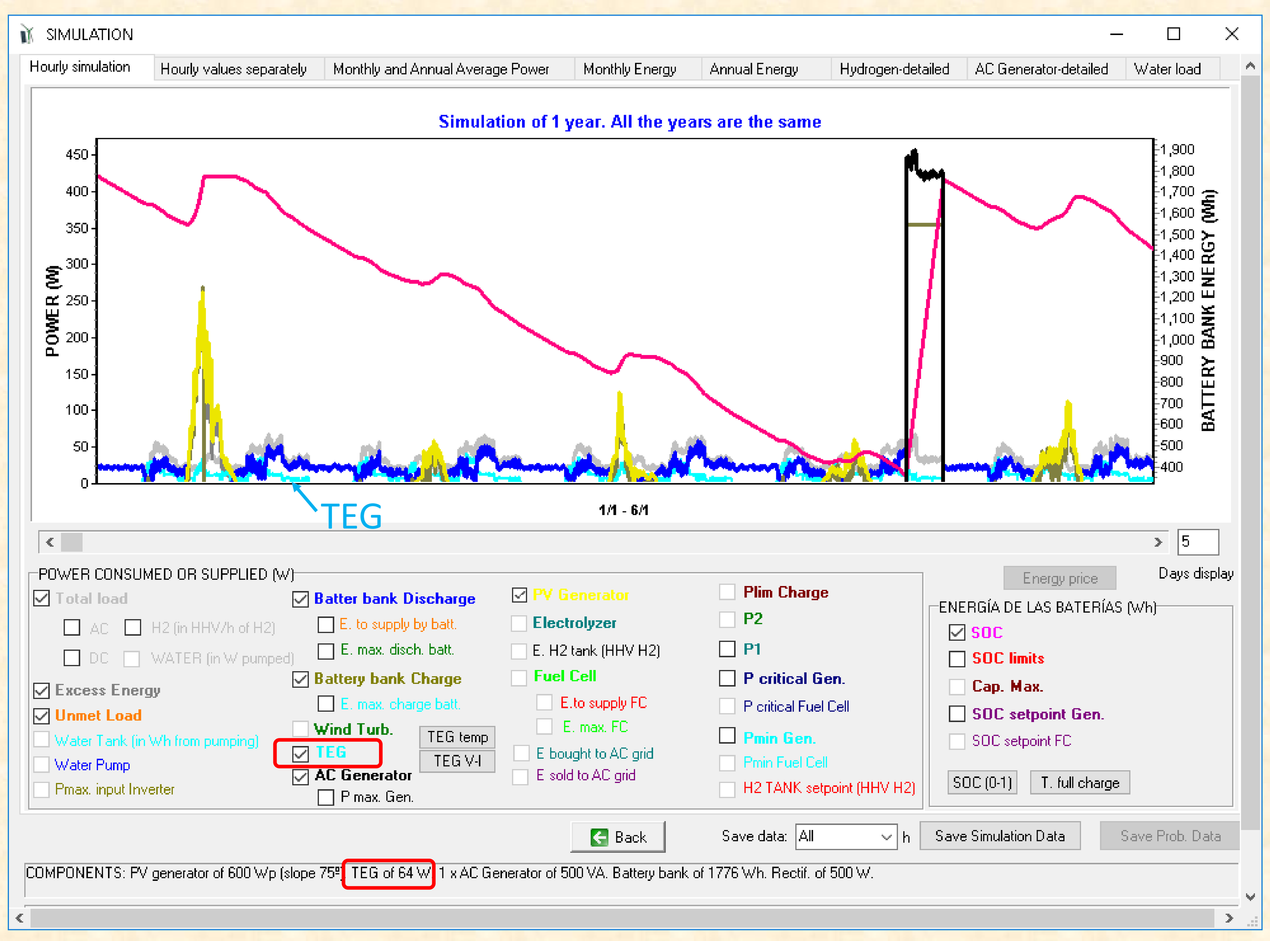


Fig. 7. Simulation of 5 days of the optimal PV-TEG-FFG-BESS system in iHOGA

Conclusion

TEG has been included into the simulation and optimisation software iHOGA, developed by researchers of the University of Zaragoza (Spain).
TEG standard simplified model combined with the TEM manufacturer output power curves lead to good simulation results, compared to the experimental results obtained by the SIAME of UPPA.
TEG can be part of the optimal system to supply the electrical load in places with low irradiation. The optimal solution for a household in south Norway is a PV-TEG-FFG-BESS system. TEG contributes to enlarge the battery lifetime and reduce the fuel consumption of the FFG

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