Distributed power modeling and life cycle assessment

Please Read the following and visit the energy websites described below and read the introductions before Monday's class. You will need to use these programs for next week's energy assignments, so download the programs (HOMER, VIPOR and GREET) some time during the next week.

Distributed power modeling

Homer Optimization Model for distributed Power was developed by The National Renewable Energy Laboratory (NREL) http://www.nrel.gov/homer/. Homer is a simulation model that can be used to optimize standalone electric power systems for economics and performance. Inputs include electrical loads, renewable resources, and component costs, and Homer can be used to optimize a system to serve those loads. Homer identifies the lowest-cost system for a particular application by simulating the hourly performance of a number of systems and ranking them by net present cost. It can optimize combinations of renewable energy technologies such as PV-Solar and biogas for minimum cost per kWh or capital cost (HOMER 2004).

Village Power Optimization for Renewables (ViPOR), http://analysis.nrel.gov/vipor/, also from NREL, is an optimization model for designing village electrification systems. Given a map of a village and information about load sizes and equipment costs, ViPOR determines which houses should be powered by isolated power systems (like solar home systems) and which should be included in a centralized distribution grid. The distribution grid is optimally designed with consideration of local terrain, load shape, fuel price, wind speed, and wire costs (ViPOR 2004).

Life Cycle Assessment

Life cycle assessment (LCA) is often referred to as a "cradle–to-grave" analysis for energy systems. The analysis begins when the raw materials are extracted from the earth and atmosphere and ends when they are returned. Thus LCA attempts to quantify all the environmental impacts associated with a product or process including extraction, transportation, and processing of raw materials as well as ultimate disposal. In the US, the Society of Environmental Toxicology and Chemistry (SETAC) have developed a LCA methodology, which is published under the International Standards Organization (ISO) 1400 framework. The Environmental Protection Agency's "Introduction to LCA" (EPA/SAIC 2001) provides a basic roadmap for performing LCA.

The LCA process has four components:

1. *Goal definition and scoping* - Definition description of the product or process, identify system boundaries and impacts to be assessed.
2. *Inventory analysis* - Identify and quantify energy water and materials usage and environmental releases such as emissions, solid waste disposal and discharge.

3. *Impact assessment* - Assess the human and ecological effects of energy water and materials usage identified in the inventory analysis.
4. *Interpretation of results* - Evaluate the results to select the preferred process or product with a clear understanding of the uncertainty and the assumptions used to generate the results

When performing LCA, "embodied" impacts are often overlooked. These refer to any impacts associated with the production and use of equipment in the process. Ignoring embodied impacts can lead to erroneous conclusions. *The Economic Input-Output Life Cycle Assessment* (EIOLCA) http://www.eiolca.net/. calculator from Carnegie Mellon University's "Green Design Initiative" attempts to account for "embodied" impacts. This website allows the user to estimate the overall environmental impacts associated with producing a certain dollar amount of a commodity or service in the United States. It provides rough guidance on the relative impacts of different types of products, materials, services, or industries with respect to resource use and emissions throughout the U.S. The entire supply chain of requirements is included, so that the effects of producing a $3,000 generator, for example, would include impacts of final assembly, mining of metals, making electronic parts, etc. associated with this device (Carnegie-Mellon 2004). This life cycle assessment analysis is based upon an economic input output model of the United States, so impacts may be over or under represented if based on projected costs in developing countries.

The *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model* by Argonne National Lab (Wang 2001) http://www.transportation.anl.gov/software/GREET/index.html focuses on the carbon emissions from vehicles it considers many fuel pathways for fossil as well as renewable-based fuels. This includes fossil energy use and greenhouse gas emissions associated with the extraction, processing and transportation of these fuels. Thus, GREET is a useful tool for determining these "well to tank" carbon emissions and fossil fuel use associated with the processes considered in this study.

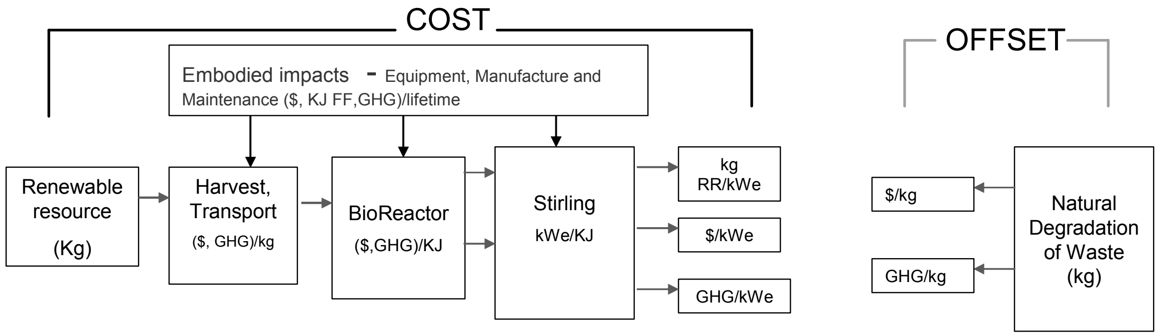

Figure 1. Biogas/Stirling life-cycle model

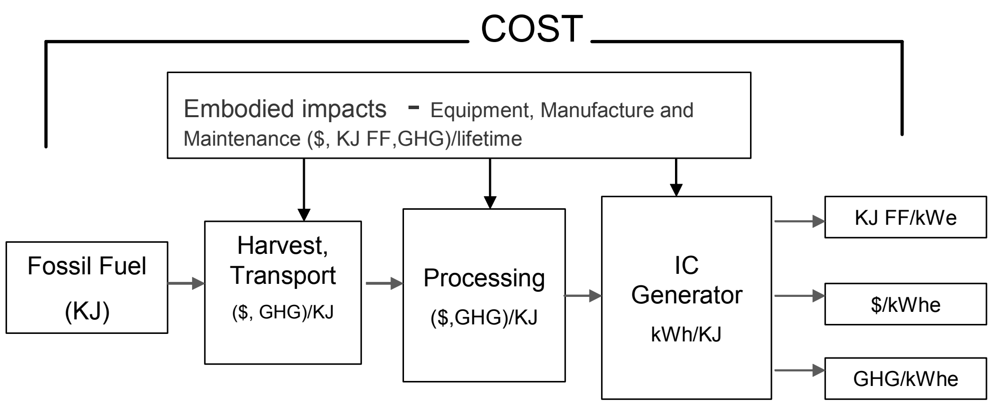

Figure 2. IC generator life-cycle model