Intellectual Property

There are several already filled patents relating the use of various energy generating sources coupled with a secondary industry process like methanol production. These patents, mostly from big industry leaders like General Electric, Hitachi, Mitsubishi and Toshiba, mostly differ in interconnection designs, energy generating sources and the method in which energy is transferred from the generating source to the industry process. Furthermore, another patentable field of special interested is the energy network itself. Energy network being the plurality of power stations and a variety of loads interconnected by an electricity grid. It is clear, by the accelerating number of patents filed in this industry area in the last years, that there is a great possibility for value. These systems are not only design for better energetic efficiency but also to have a huge economical advantage versus conventional systems. If an efficient overall system can be design, patenting this design(s) can offer a competitive advantage versus other similar systems with less efficiency and capabilities. Once filed it would be beneficial for the world to have these ideas be public domain as global warming and pollution is a challenge that we are all facing together. If these efficient designs are not patented, the competition might do it without any intend of opening the patents to public domain. These types of IP’s may generate revenue in a variety of ways mainly either licensing the design or by offering to build and operate these types of systems to clients be it counties to states.

Ethics

The National Society of Professional Engineers Code of Ethics requires all projects to be done with “honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare”. One the main purposes of developing this type of technologies and electrical networks is to help tackle the global warming issue while improving reliability, safety, and cost-effectiveness. As with any other technology there are many possible unintended consequences, especially when the technology has only been developed theoretically and prototypes do not exist. The work being done in every stage of the project is set around minimizing these possible consequences. Some of examples of possible consequences for every stage of the project are listed as follow:

Table X. Possible Unintended Consequences

|  |  |  |  |
| --- | --- | --- | --- |
| Stage 1: Design and Virtual Simulation | Stage 2: Test | Stage 3: Build | Stage 4: Use |
| Failure to correctly design certain components of a complex system. | Prototype does not work as intended. | Theoretical designs and tests slightly different from reality causing redesign. | Hydrogen Production Malfunction |
| Goals not reachable due to shortness in team members, time and expertise. | Regulatory bodies request additional information causing unexpected delays. | Project acceptance problems by the local community of the selected location. | Radioactive Contamination of secondary loops. |

Each of these possible unintended consequences probability will be minimized as much as possible as per the Code of Ethics for Engineers, “holding paramount the safety, health, and welfare of the public”. In any stage of the process, all engineer members “shall avoid all conduct or practice that deceives the public” by providing public statements in an objective and truthful manner.

Our Proposal

To deal with the previously mentioned challenges, we need the ability to “load follow” or match the energy output to the demand to prevent financial losses from excess energy being supplied to the grid when demand is low. Current nuclear reactors do not have this ability to ramp up or down their electricity production fast enough and thus are not able to effectively load follow. On the other hand, renewables don’t have the efficiency nor capacity to supply energy to the entire population. To fix these issues, we propose a nuclear-renewable integrated energy system consisting of an advanced nuclear reactor, specifically a molten salt reactor, coupled with a secondary industry process and a solar and wind farm.

*Main Electricity Generating Technology – Molten Salt Reactor*

The molten salt reactor is a generation IV fission reactor and it is based on the molten salt reactor experiment carried in the 1960s at the Oak Ridge National Laboratory. This class of reactors has many advantages compared to current pressurized water and boiling water reactors where the main advantage is that it uses a liquid fuel salt rather than solid fuel rods. The fact that it uses molten salt mitigates the need for a highly pressurized system necessary in light water reactors and the design comes with countless passive safety mechanisms that make it “walk away safe”.

*Secondary Industry Process – Hydrogen Production*

The purpose of the secondary process is to take in excess energy in order to create a useful commodity that can later be sold. This helps load following efforts and an ideal process would be able to change production intensities to match different energy surpluses. On the more technical side, there are many adequate choices for the secondary process that depend on the thermal or electric requirements. Based in the fact that our reactor has an outlet temperature of around 700C we selected a four-step copper chloride hydrogen production process which only needs temperatures of upwards of 550C.

*Overall System Dynamics*

Since solar and wind are cyclical throughout the day, meaning that they only work when there is sun and/or wind, they will supply all the energy they produce to the electrical grid. The nuclear reactor will provide the other portion of the required electricity and the excess energy will be use to produce hydrogen. The hydrogen will be stored in pressurized tanks and sold in the market for a profit. This combination of processes means that all the energy will be use in more intelligent and efficient manner. When demand peaks, the hydrogen production rate can be stopped or slowed and during lows the rate can be resume or increase. The overall system then becomes efficient and highly profitable but more importantly it solves the problem with nuclear and renewables sources in an environmentally friendly way.

All members of the team will be working together in the design and integration of the individual technologies in a single system and work in the automatization of the overall grid/process. This will involve looking at the individual technologies and describing them in a detailed way to be able to interconnect them. This will be facilitated by the fact that the only design constraint is that the hydrogen plant needs to be directly coupled with the reactor. The solar and wind farms can be situated in different sites as long as they are connected to the same grid. An example of the system is portrayed in Figure 1 from the Idaho National Laboratory where the Nuclear energy sources is supplying heat to the power generation island and the hydrogen industry process through a variety of heat exchangers. In this example there is a thermal energy storage facility which then splits the thermal energy depending on demand and the processes requirements.

FIGURE 1. Nuclear-Renewables Integrated System from Idaho National Laboratory (Bragg-sitton et. al. 2016). This system is formed of a Nuclear Energy power plant, wind and solar generating technologies and various industrial processes.

The first main challenge in the capstone project is the interconnection of the molten salt reactor and the hydrogen production plant. Once the system design is complete the next challenge is to find a way to automatize the whole grid to make it as efficient, economically and energetically, as possible. This means building an intelligent system capable of balancing the electricity output, from the nuclear reactor, and the hydrogen production rate depending on the grids demand and all this without the need of human operator’s intervention. The automatization design process will involve the modeling and simulation of different real-life scenarios where energy demand varies during the day. The system should be able to adapt to these scenarios and run smoothly, safely and efficiently. Once all these goals are achieved the project will be complete.