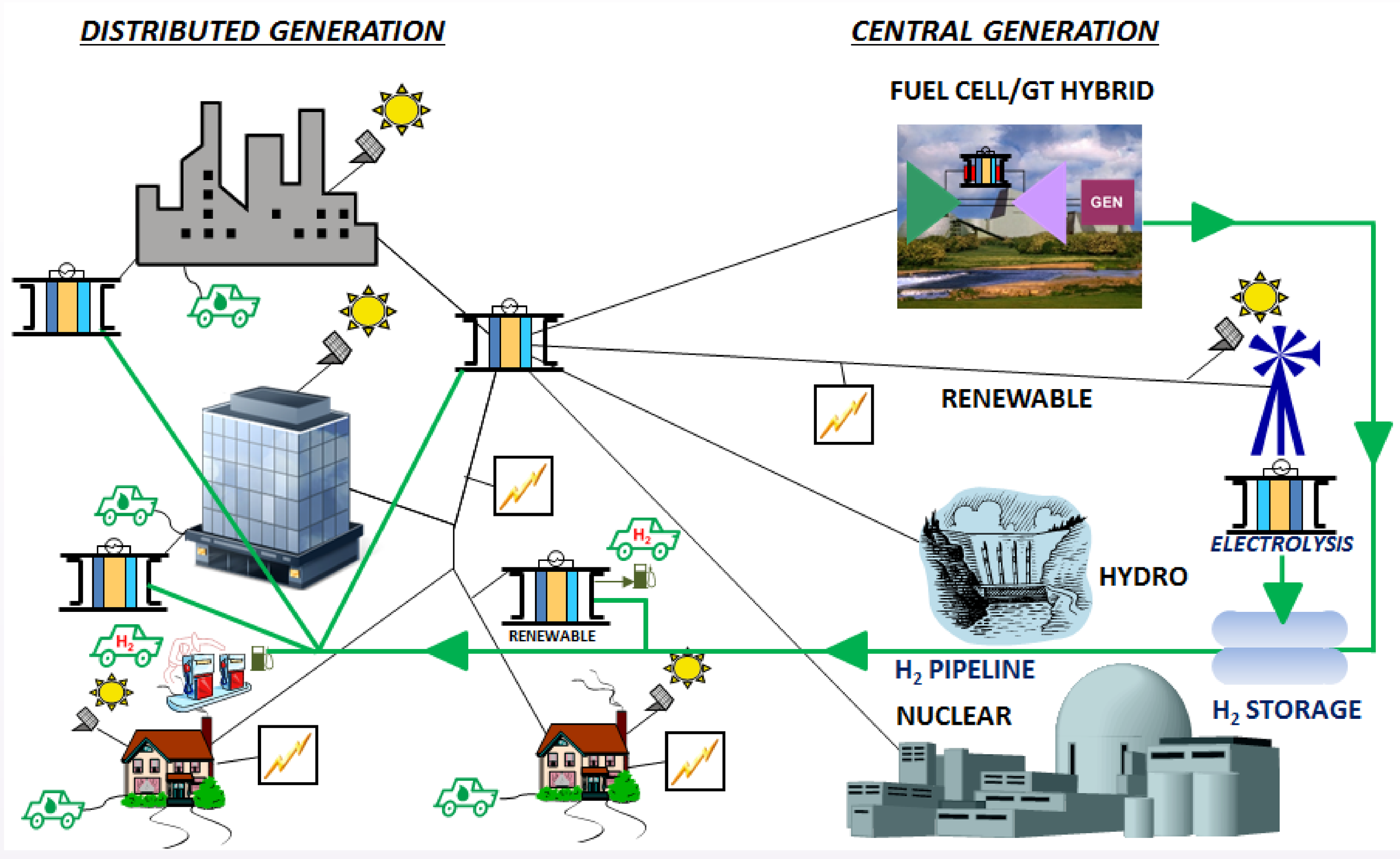
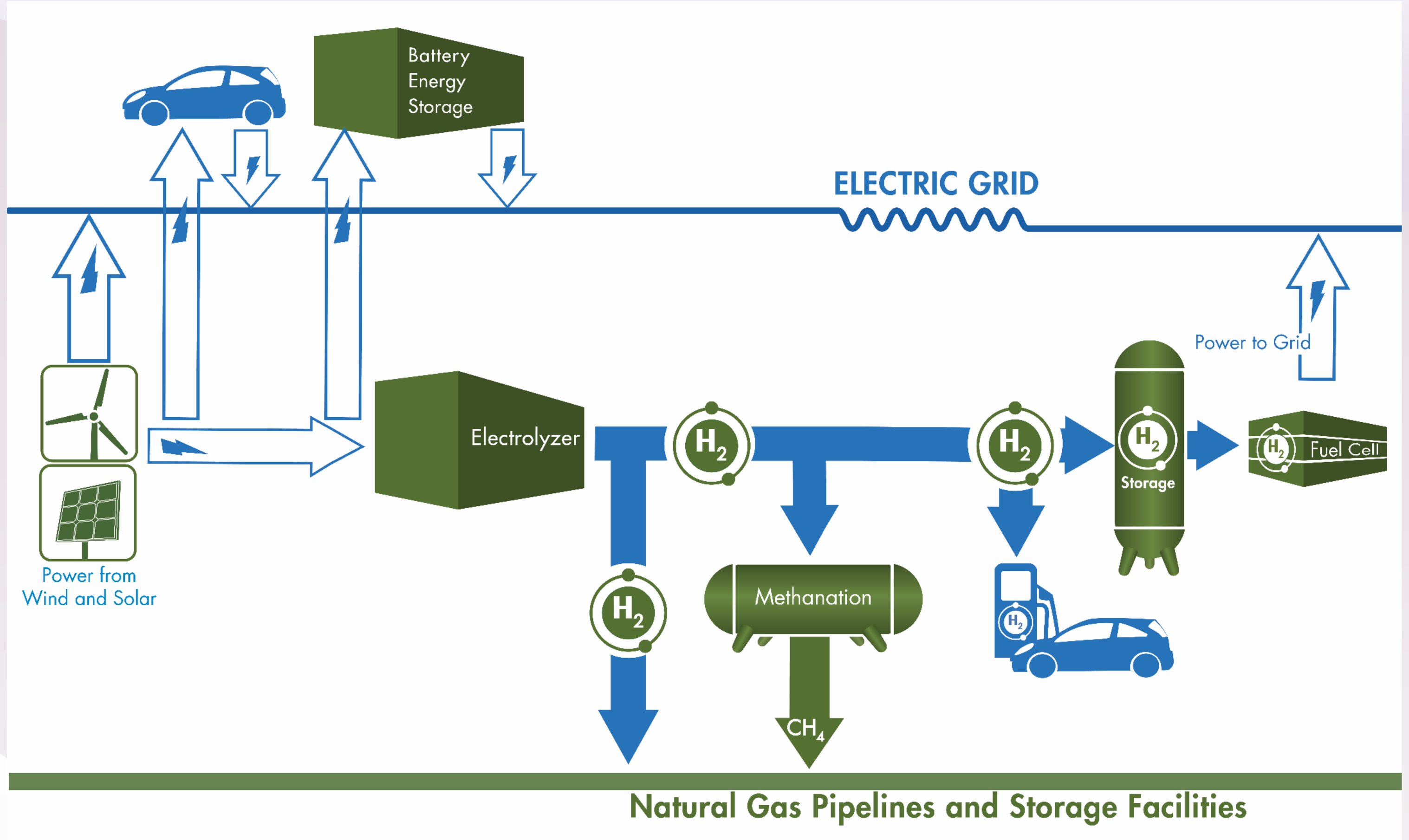
The Future Grid

OVERVIEW

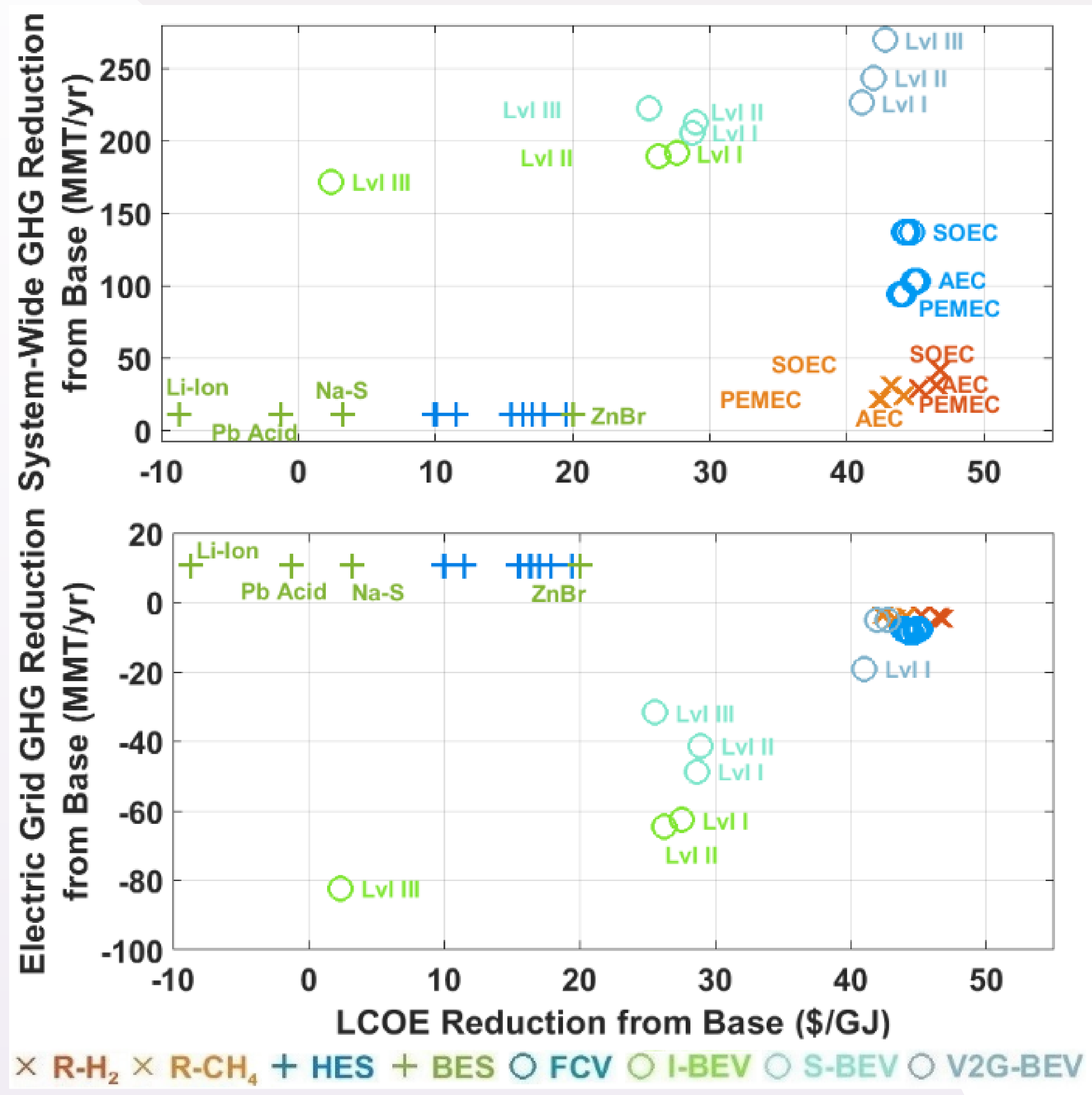
California has enacted measures to reduce emissions of greenhouse gases (GHG), such as CO_2, by setting emission targets which motivate the integration of renewable energy resources into the electric grid. However, due to the variability of solar and wind availability, renewable generation may exceed the electric demand resulting in curtailment of excess renewable energy. These curtailment events are already occurring in today's California electric grid. As installed renewable capacity increases, a necessity to capture the excess renewable energy is apparent.



Overview of the future electric grid



Overview of the end-use scenarios.



Reduction of system-wide and electric grid GHG emissions versus LCOE of each technology pathway from an 80% renewable penetration base case.

GOALS

(1) To determine the effects of utilizing excess renewable energy, in an electric grid with high renewable penetration. (2) To reduce system-wide GHG emissions and levelized cost of energy (LCOE) through the following end-uses:

- Battery and hydrogen energy storage to offset electricity generation from fossil-fuel power plants. (HES, BES)
- Production of renewable gas such as hydrogen or methane to offset the usage of natural gas for heating or industrial processes. (R-H_2, R-CH_4)
- Production of transportation fuel for zero emission vehicles (ZEVs) to replace gasoline vehicles by producing hydrogen for fuel cell vehicles or electricity for charging battery electric vehicles. (FCV, x-BEV)

RESULTS

The proposed end-uses consist of multiple technology pathways which include different equipment types such as an alkaline electrolyzer coupled with a solid oxide fuel cell Each of the proposed technology pathways reduce system-wide GHG emissions compared to a base case which does not implement any of the excess renewable generation end-uses at the same renewable capacity. The GHG reduction primarily depends on the GHG emissions from the replaced technology. For example, replacing gasoline vehicles with ZEVs result in the highest GHG emission reductions due to higher GHG emissions from gasoline combustion compared to natural gas combustion.

The reduction of system-wide LCOE of each technology pathway primarily depended on the ability to utilize excess renewable energy. Energy storage technology pathways resulted the lowest LCOE and GHG reductions due to dispatch limitations to a highly renewable electric grid. Energy storage can only dispatch and offset a small percentage of the electric demand which is undersized compared to the availability of excess renewable energy in a high renewable penetration electric grid. However, energy storage is the only end-use that reduces GHG emissions from the electric grid. Therefore energy storage must be coupled with another end-use, such as ZEV transportation fuel or production of renewable gas, in order to fully utilize the excess renewable energy.

PERSONNEL

Graduate Student: Sarah Wang
Staff: Dr. Brian Tarroja, Dr. Lori Schell, Dr. Li Zhao,
Professor Jack Brouwer, Dr. Jeffrey Reed
Principal Investigator: Scott Samuelsen
Advanced Power and Energy Program
University of California, Irvine

ADVANCED POWER & ENERGY PROGRAM
www.apep.uci.edu

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