ENERGY STORAGE

An energy storage system built into Palamanui’s grid would allow the development to incorporate more intermittent renewable energy, increase grid stability, and help eliminate peak demand. Large central storage systems and smaller scale systems allow developments to eliminate peak demand and evenly distribute their daily load curves, known as peak load shaving. Systems draw energy from the grid during periods of low demand with excess generation; storing the energy until it is returned to the grid during peak demand. Three methods of accomplishing this task are further explored below:

Plug In Hybrid Vehicles
Battery Banks
Compressed Air Storage

Battery Banks

**Central Storage** - One large battery bank for the entire development.

**Block Storage** - Smaller banks for blocks of homes and/or businesses.

**Individual Storage** - Each home has personal battery storage system.

Compressed Air Storage (CAS)

**CAS Cycle:**
- Compress ambient air during times of low demand with excess energy from HELCO and/or solar panels.
- Store compressed air in steel pipes.
- Expand compressed air through turbine to produce electricity during times of peak demand (6pm to 10 pm).
- Expand with Natural Gas (more efficient, greater energy output, current systems operate this way).
- Expand without natural gas (less efficient, opportunity for cooling with exhaust air, heating with stored air).

**CAS with Natural Gas:**

More Information:
- Palamanui would require roughly 2.5MW of peak generation.
- Two large plants in operation today.
  - Hunzol CAES, Germany (290 MW).
  - McIntosh CAES, USA (110 MW).
- Lifetime greater than 30 years.
- 3 times the amount of generation from turbine when combined with pre-compressed air.
- For a normal gas turbine, 2/3 of generation goes to compressing in coming air.
- Excess heat can be used for cool/heating depending on system.

Vehical to Home (V2H)

**Purpose:**
- Supply the houses during peak hours.
- Backup energy for the houses during outages.
- Cleaner transportation.
  - Charge from solar panels during the day.
  - Could also charge during night when demand for electricity is low.
  - Fewer trips to the gas station.

More Information:
- Possible to buy retrofitted PHEVs.
- Car manufacturers are all planning for some kind of hybrids and PHEVs.
- Battery sizes are around 16kWh, or ~40 miles in full electric mode.
- PHEVs will be more expensive, but prices will go down with better technologies and more production.

Communication

Easiest way is to connect the car and the house when the electrical cable is connected.

The basic information needed between the PHEV and the house is:

- **PHEV to House**
  - Battery state of charge
  - Minimum charge required for the driver and when

- **House to PHEV**
  - When discharge is needed

Below are two plots of Palamanui houses with PV panels, and PHEV that comes home at 4 PM and leaves at 8 AM. The simulation is run for a week.

Helco gets more electricity than they provide, and the only load is during night when these PHEVs are charging.

**Larger house and PHEV (16kW):**

<table>
<thead>
<tr>
<th>Component</th>
<th>Larger</th>
<th>Smaller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total house consumption</td>
<td>295 kWh/week</td>
<td>185 kWh/week</td>
</tr>
<tr>
<td>Helco</td>
<td>-180 kWh/week</td>
<td>-242 kWh/week</td>
</tr>
</tbody>
</table>