Energy Storage – the Foundation for a Renewable Energy Future

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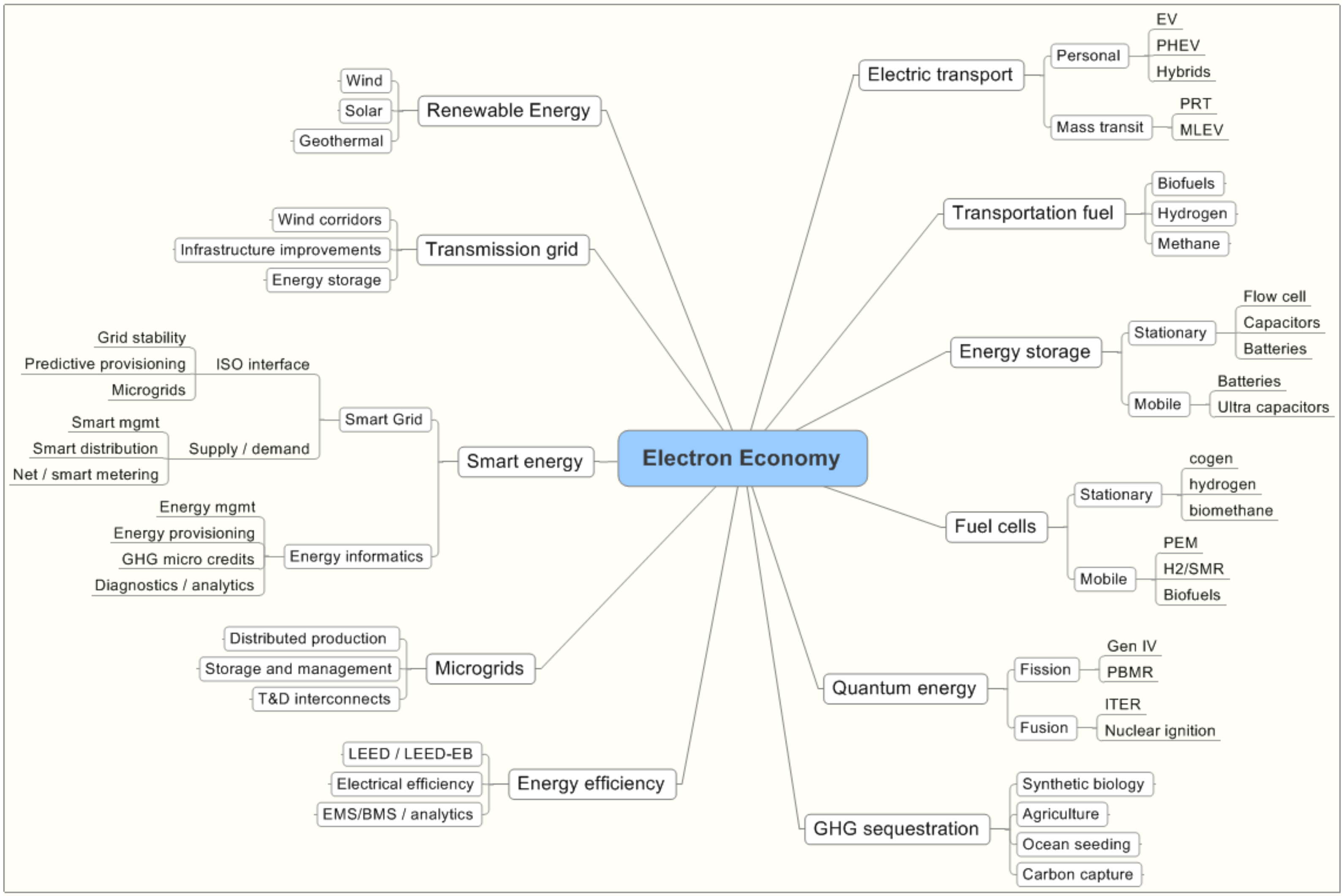
Foothill College

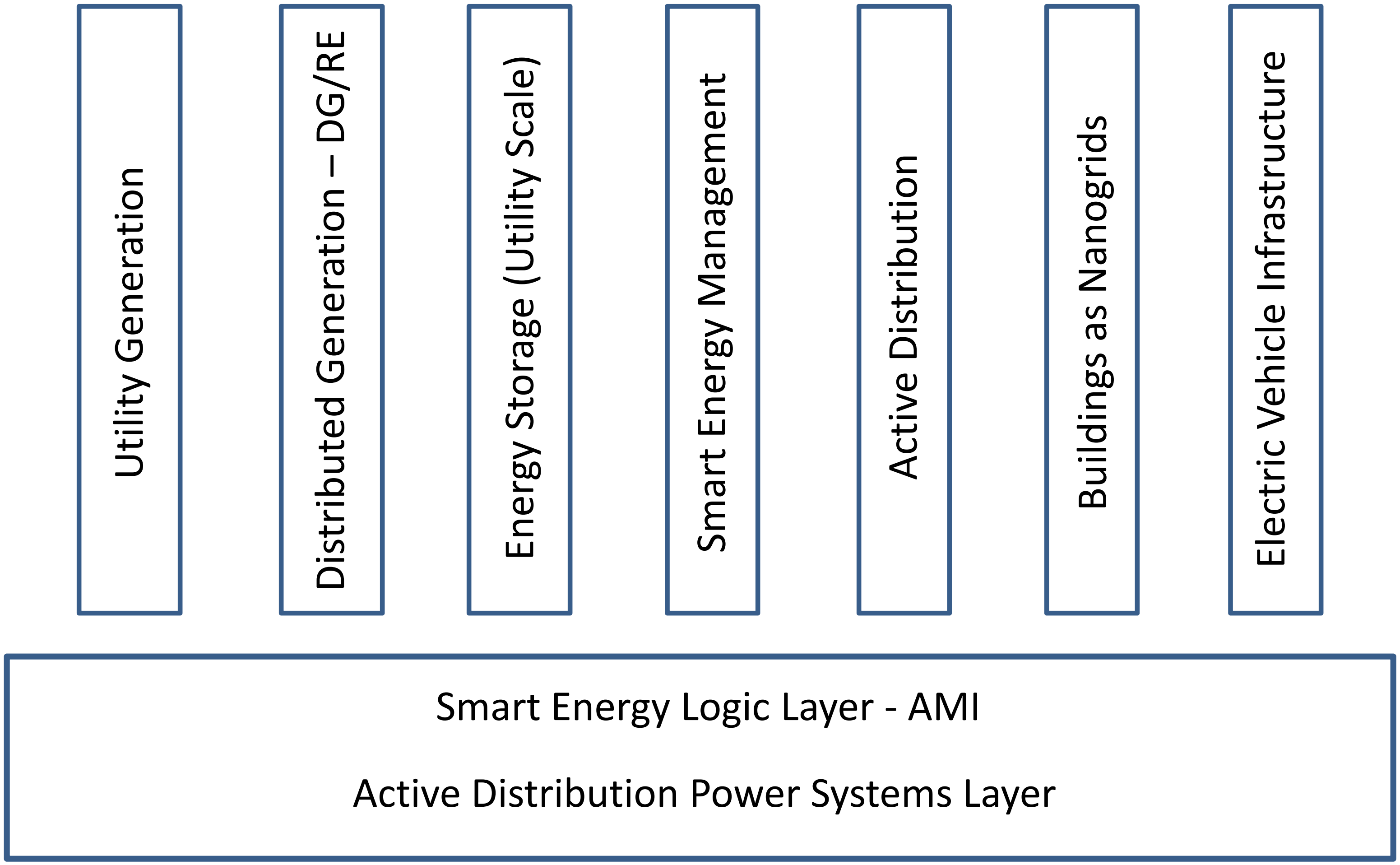
Overview

- ***Electron economy***
  – Smart Energy platform
- ***Micrograds => Nanogrids***
  - Managed grids => IDSM
- ***Renewable Energy*** + ***Energy Storage***
  – What are the requirements?
  – What roadmap gets us there?

Electron Economy



e⁻ Application Platform



Nanogrids => Component Model

- ***Homes***
  - Onsite energy
  - Onsite storage
- Solar ***BIPV***
- ***EV charging***
- ***Smart energy*** meter / mgmt
- ***Smart appliances***

- ***Role of storage***
  - Capture excess PV energy (vs. export)
  - Store cheap energy from 12 to 5 am
  - Blended energy
  - Power quality
  - Demand Response
  - ***Resilience***


Home Energy Manager
The central nervous system for the net zero energy home helps homeowners optimize energy consumption.
Solar Photovotaic
3 kW to 4 kW solar array on the roof to meet energy requirements of the home.
Small Wind
Supplementary renewable generation.
Smart Meter
A communication gateway between the Smart Grid and the home.
Energy Efficient Lighting
High efficiency CFL, LED and OLED lighting.
Geothermal Heat Pumps
Reduces HVAC and water heating energy requirements by 30%.
Demand Response Appliances
High efficiency Energy Star Appliances shed load from the grid and help consumers save money during peak demand.
Energy Storage
Battery storage for backup power and peak loads.
GE Heat Pump Water Heater
Uses less than half the energy of a conventional electric water heater.
GE Water Filtration
Filters, conditions and monitors home water usage.
imagination at work

NASA-ASL Nanogrid

- ***3 KW Solar PV (off grid)***
- 8 40 Amp Pb-A batteries (~4 kWh)
- 120 V outlet for level 1 EV charging
  - ***Need ~1.8 KW for 5-8 hours (~12 kWh)***
- Purpose: charge an EV for 5-8 hours
- Provide PV energy to EV transportation
- Analyze round trip energy / optimization

UCSC / NASA-ARC ASL Nanogrid


ASL
Advanced Studies Laboratories
Data Collection In Progress
Parking Space
RESERVED
for PhotoVoltaic Testbed (PVoT) electric vehicle charging data collection
ASL
Advanced Studies Laboratories
Data Collection In Progress
Parking Space
RESERVED
for PhotoVoltaic Testbed (PVoT) electric vehicle charging data collection
ASL
Advanced Studies Laboratories
Electric Vehicle
Volunteers Wanted
for plugging into PhotoVoltaic Testbed (PVoT) to collect EV charging data
6YQF762
California
RAV4
EV


TOYOTA

3KW Solar PV Nanogrid

Solar Garage – Solar Barn Deployment

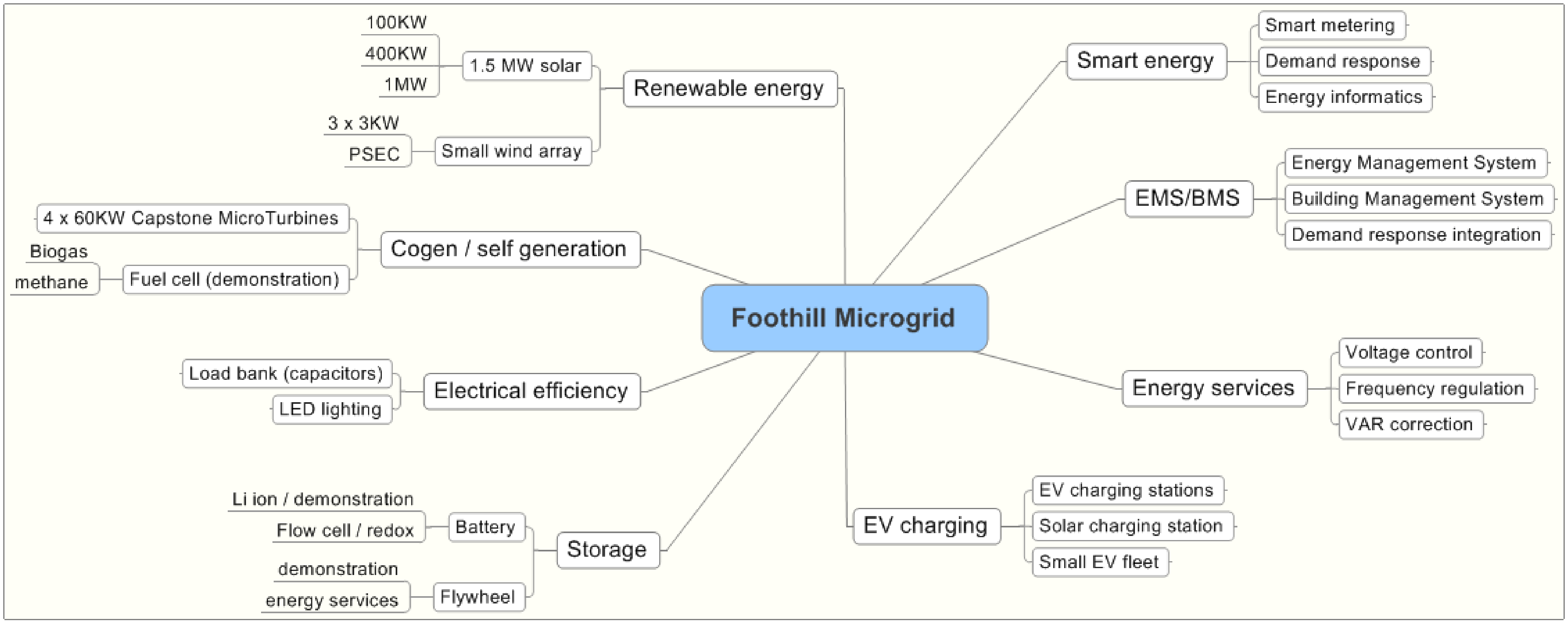
Roundtrip Energy Analysis

- ***3KW solar PV - 4 kWh storage => EV***
  - 120V 15 amp Level 1 charging
  - Delivers ~ 12 kWh of energy / sunny day
  - Energy storage needs to be sized higher
- ***3 KW 'solar barn'***
  - 2.5 KW PV * 5 hrs => .5 -1 KW avg load
  - Need ~ 8 – 10 kWh local energy storage
- ***Nanogrid/Microgrid storage apps large!***

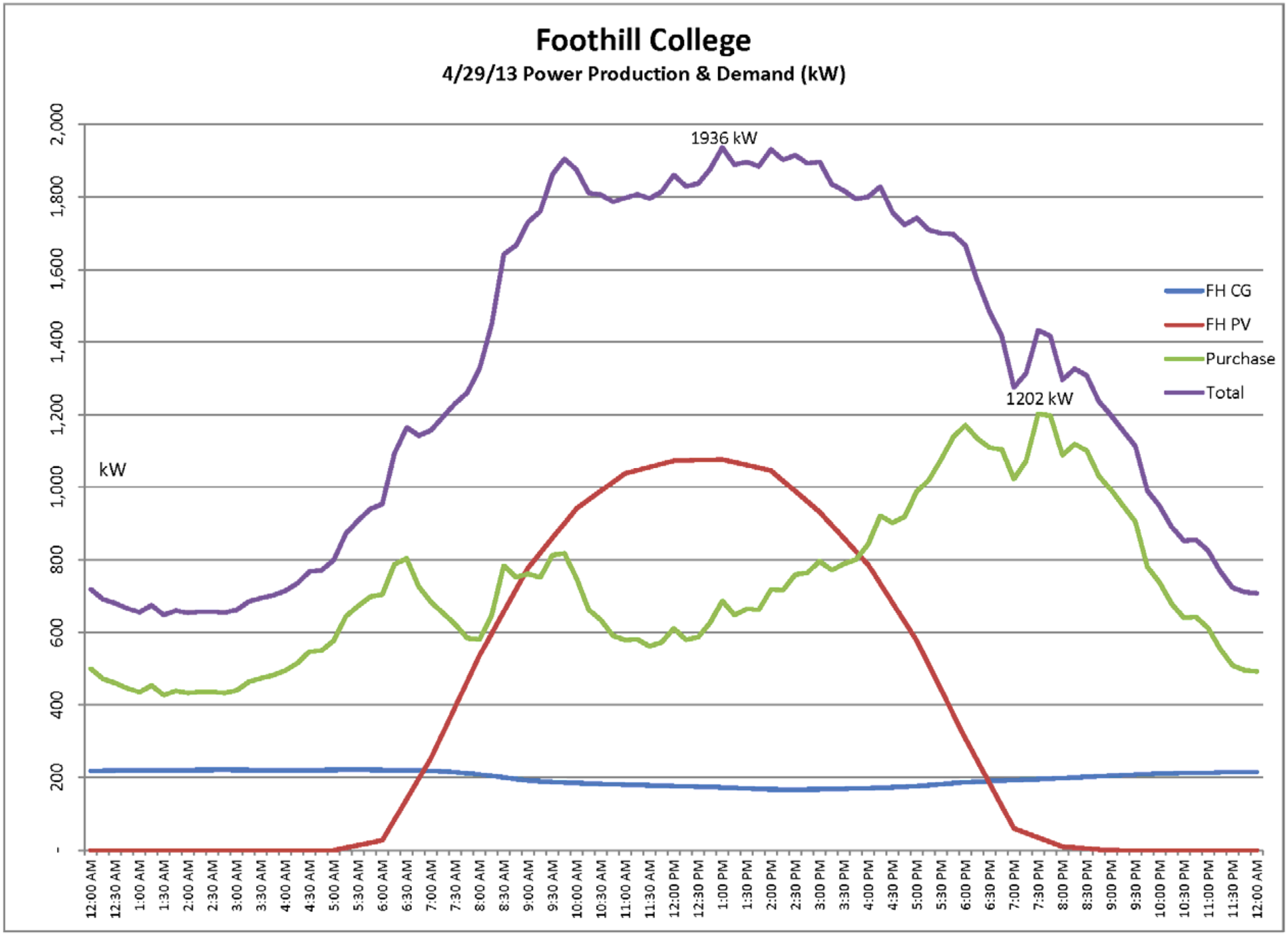
Microgrids => Managed Grids

- Generation
  - ***Onsite PV plus utility***
- Energy storage ~ 1 MWh
- Load (buildings, EVs)
- Smart energy mgmt (IDSM)
- Active distribution
  - ***Manage building load***
  - ***Blend energy storage***

Foothill Campus Energy Map



Foothill College is the ideal test bed for innovative energy technology for ***clean generation, smart distribution, and efficient end use***


Foothill College
4/29/13 Power Production & Demand (kW)
kW
1936 kW
1202 kW
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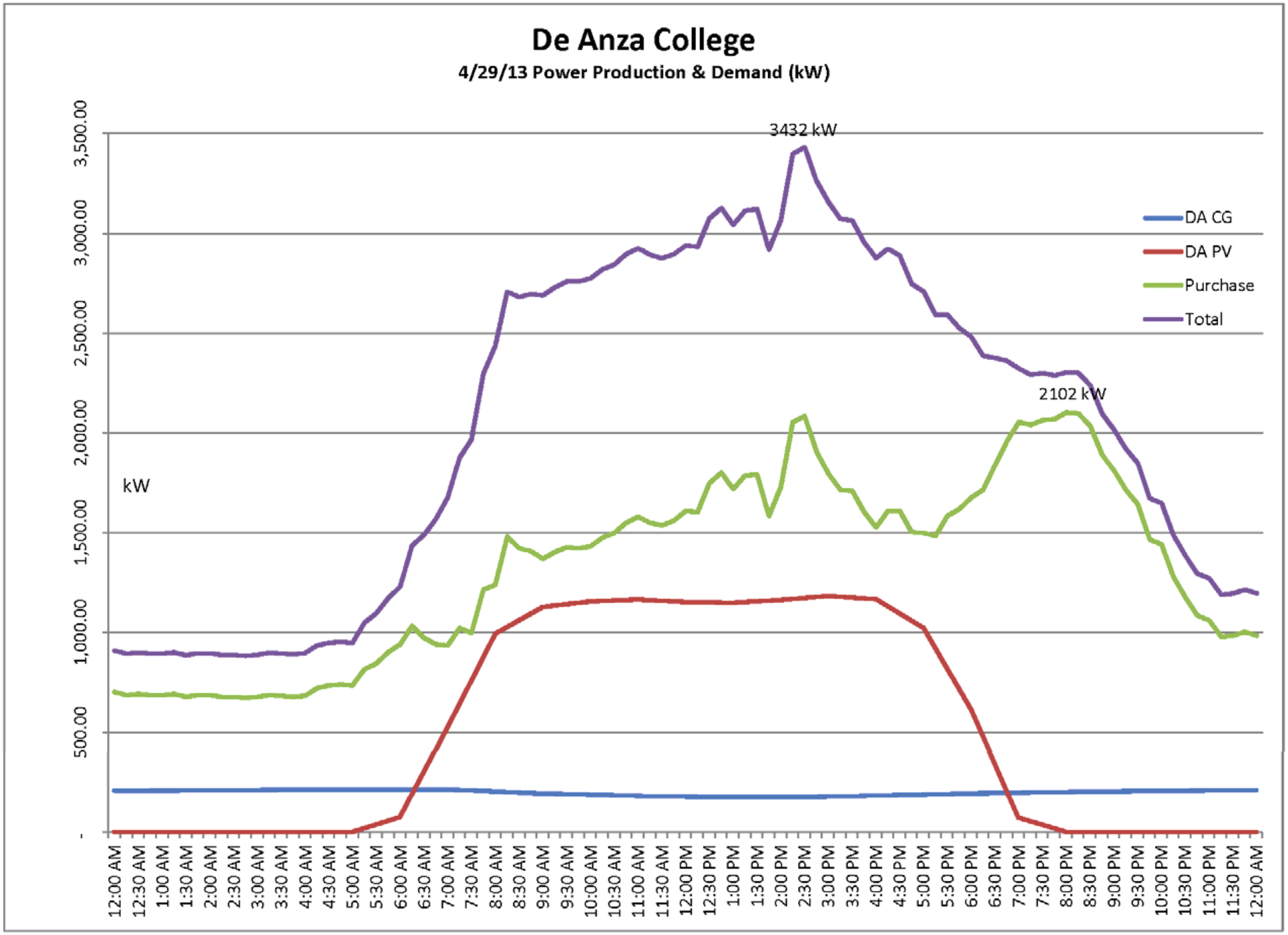
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4/29/13 Power Production & Demand (kW)
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2102 kW
kW
DA CG
DA PV
Purchase
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Utility Scale Storage

http://cleantechnica.com/2013/06/09/5-mw-lithium-ion-energy-storage-system-unveiled-in-oregon-will-provide-storage-for-intermittent-renewable-energy-sources/

“Managed Grid” Storage

- Blended energy feeds
  - ***Utility plus onsite solar (DG)***
- Managed building loads
  - ***BEMS and BAC mgmt tools***
- Arbitraged energy
  - ***Buy low => sell high***
- Demand Response (DR)
- ***Integrated Demand Side Management (IDSM)***

Building Integrated PV

Produce ~ 1 to 2x average demand, storage sized 1-2x excess KW

The “ZNE Challenge”

- ***Zero Net Energy annualized***
- ***Zero Net Emissions*** (PV vs. fuel cell)
- Solar PV produces 1,500 hours a year
  - ***Buildings need 8,760 hours of energy***
- ZNE buildings are high efficiency (low load)
- PV will ‘over produce’ by 3x during the day
  - ***Reverse power flow*** on distribution grid
  - Energy storage can ***‘level’*** the power flows

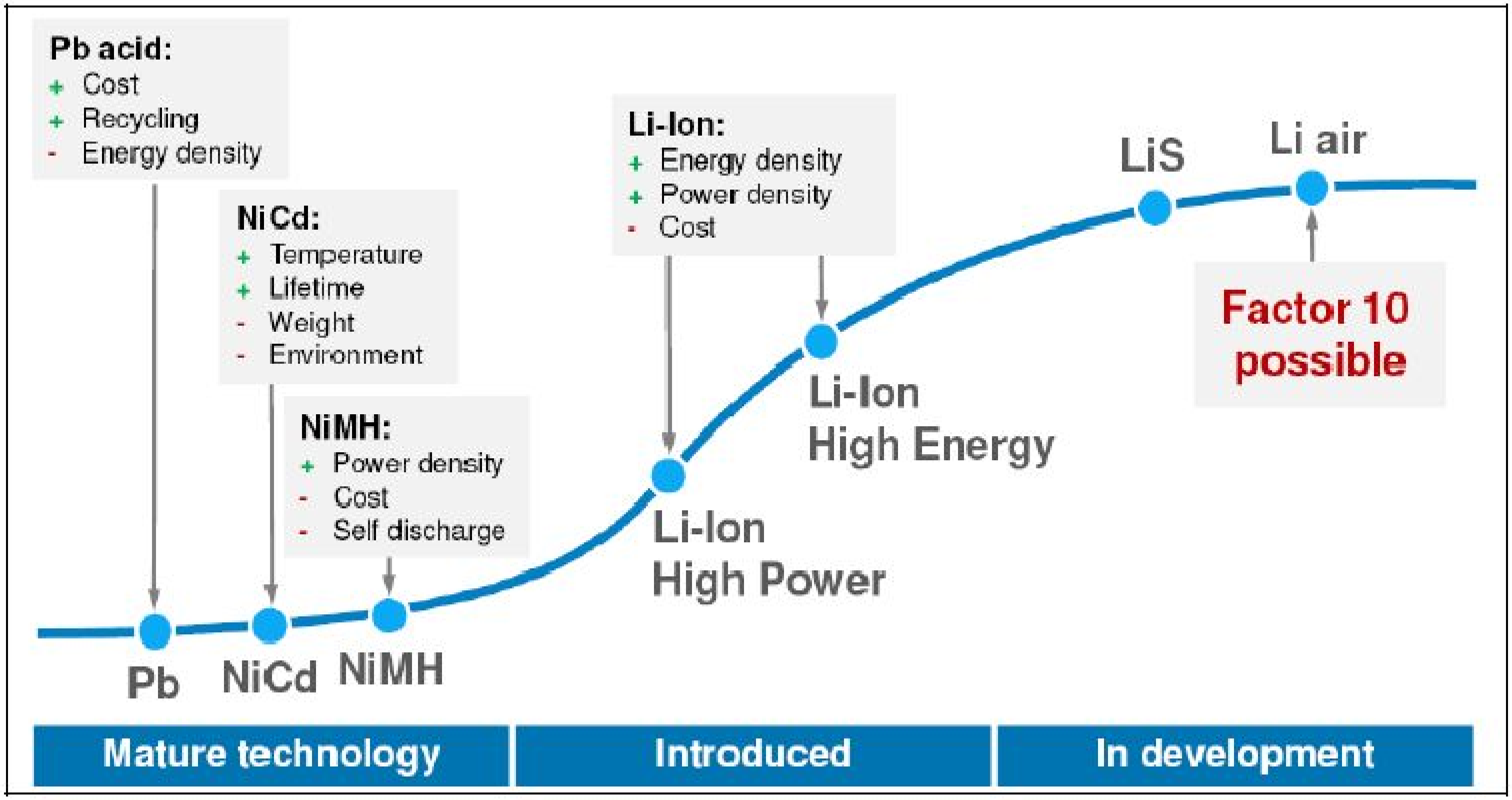
NASA Sustainability Base

RANGE - Robust Affordable Next Generation Energy Storage Systems

This program seeks to fund the development of transformational electrochemical energy storage technologies that will accelerate widespread electric vehicle adoption by dramatically improving their driving range, cost, and reliability. To achieve this long-term objective, this program aims to **maximize specific energy** and **minimize cost of energy storage systems** at the vehicle level. Central to this system-level approach is the use of robust design principles for energy storage systems. Robust design is defined as **electrochemical energy storage chemistries and/or architectures** (i.e. physical designs) that **avoid thermal runaway and are immune to catastrophic failure** regardless of manufacturing quality or abuse conditions. In addition, this program seeks **multifunctional energy storage designs** that use these robust storage systems to simultaneously **serve other functions** on a vehicle (for example, in the frame, body, and/or crumple zone), thus further **reducing an energy storage** system's **effective weight** when normalized to the entire electric vehicle weight. It is anticipated that the core technologies developed under this program will advance **all categories of electrified vehicles** (hybrid, plug-in hybrid, extended-range electric, and all-electric vehicles); however, the **primary focus of this program is on all-electric vehicles**, referred to hereafter as electric vehicles (EVs).

Mobile Energy Storage Roadmap

Battery technology roadmap



http://www.intechopen.com/books/new-generation-of-electric-vehicles/the-application-of-electric-drive-technologies-in-city-buses

Lithium Ion Four Pack Battery for mobile apps

A **lithium-ion battery** (sometimes **Li-ion battery** or **LIB**) is a member of a family of rechargeable battery types in which lithium ions move from the anode to the cathode during discharge and back when charging. Li-ion batteries use an intercalated lithium compound as the electrode material, compared to the metallic lithium used in non-rechargeable lithium battery.

Specific energy 100–265 W·h/kg(0.36–0.95 MJ/kg) Energy density 250–730 W·h/L

(0.90–2.23 MJ/L) Specific power ~250-~340 W/kg Charge/discharge efficiency 80–90%[3] Energy/consumer-price 2.5 W·h/US$

http://en.wikipedia.org/wiki/Lithium-ion_battery

Mobile Energy Storage

Energy Storage Materials

- Pb-A
- NiMH
- Lithium
- Silicon
- Carbon
- Vanadium
- Molten salt

- **Specific energy**
  - Increase by 3x
- **Power density**
- **Cycle / durability**
  - 5,000 cycles
- **Safety**
- **Cost**
  - Decrease by 2-3x

Summary

- Energy storage needed for RE
- Especially for ZNE buildings
  - ***Reduce reverse power flows***
- Managed grid applications
  - Reduce peaks, enhance power quality, automated demand response (ADR)
- Technology curves need to accelerate
- Mobile and utility apps are different