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Los Alamos National Laboratory Modular Pumped Hydro Feasibility Study for Santa Fe Community College

Energy Storage Workshop Presentation At Santa Fe Community College

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LAUR-15-xxxxx

First - Why Energy Storage?
Better Utilize Our Water and Fuel Resources

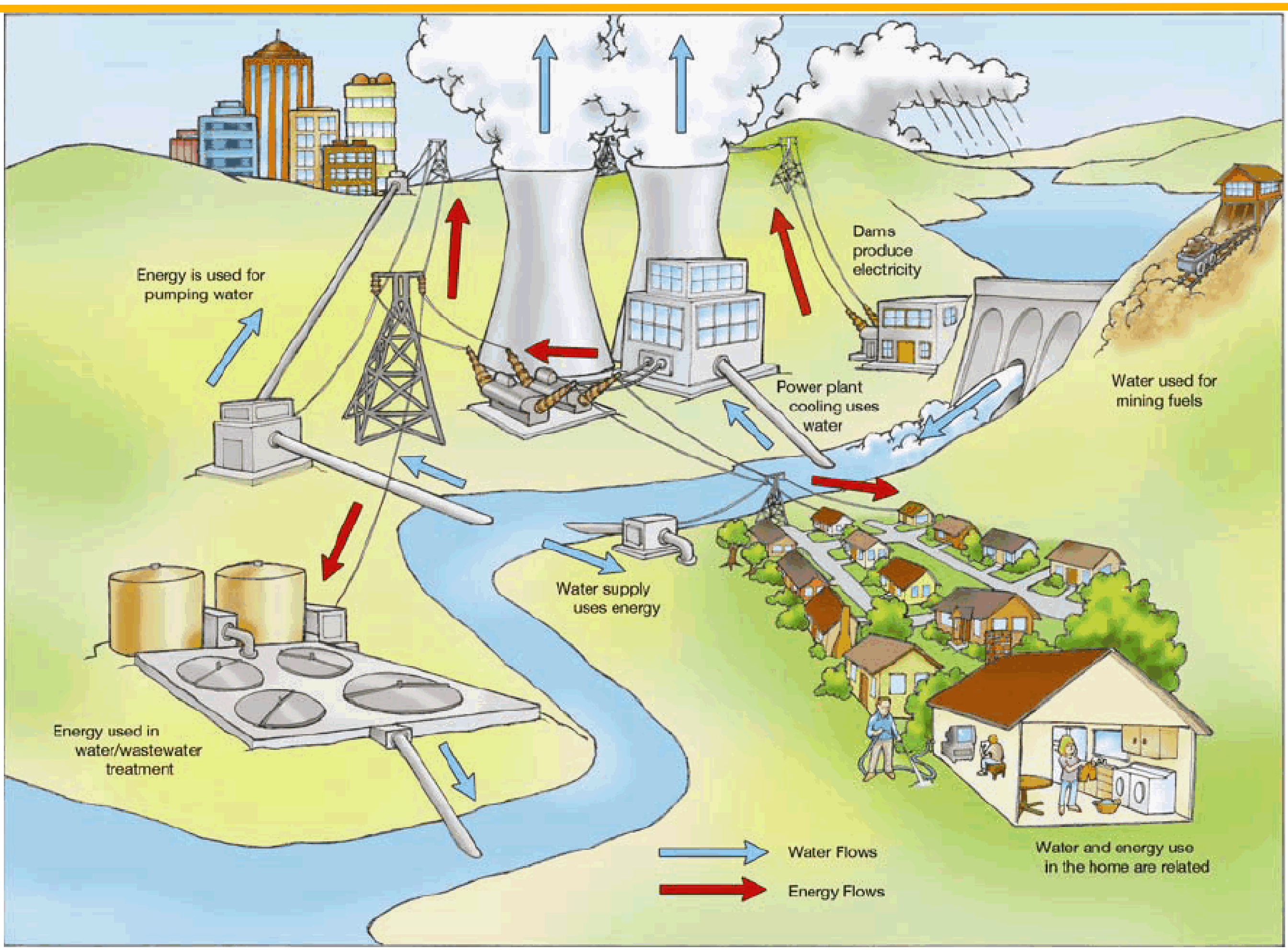
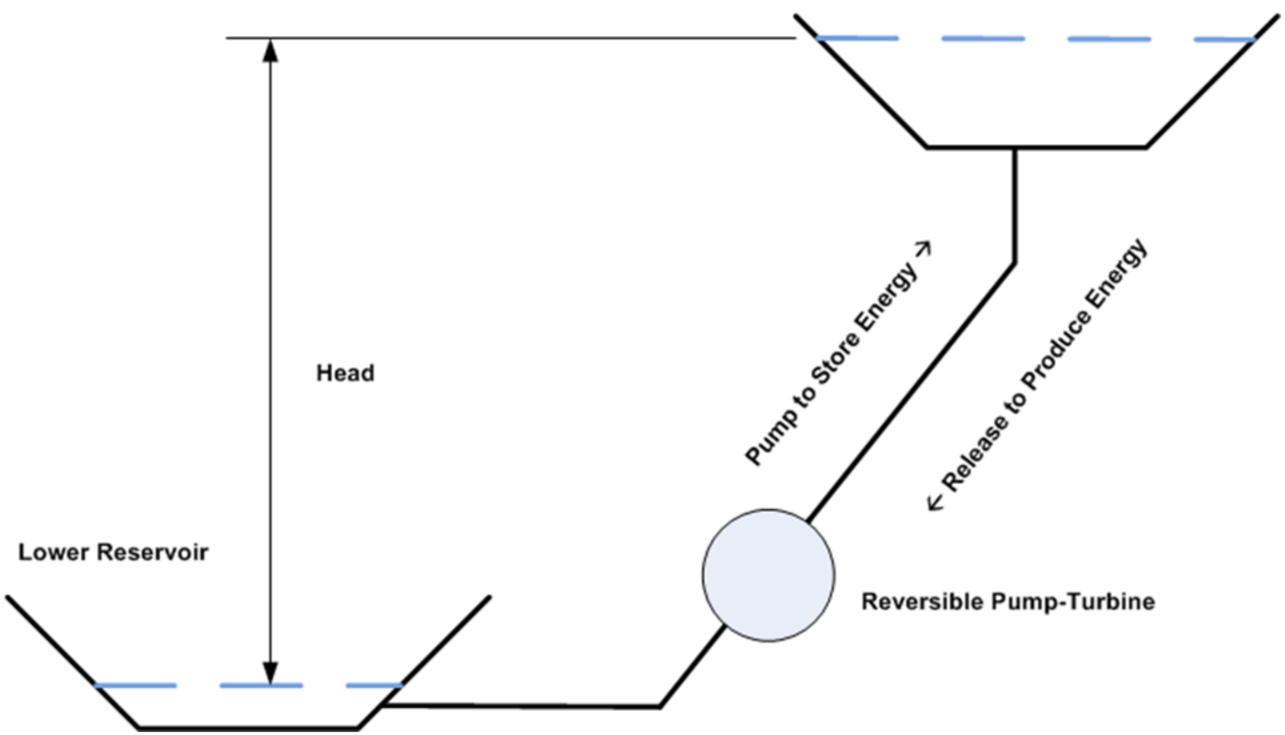


Figure I-1 of “Energy Demands on Water Resources, A Report to Congress”, US DOE, December 2006.

Second - How Does MPH Work?

$$\text{Produced Energy} = (\text{efficiency})\ (\text{density})\ g\ (\text{head})\ (\text{volume})$$

$$\text{Joules} = \left(\frac{\text{kg}}{\text{m}^3}\right)\left(\frac{\text{m}}{\text{sec}^2}\right)(\text{m})\ (\text{m}^3)$$



What Were Our Main Goals?

- Develop a teaching tool for energy storage
  - This community has precedence with existing RE and hands-on education programs
- Evaluate if on–peak demand may be reduced using MPH with stored energy derived from local solar array and off-peak purchases
  - Looking at customer side of meter
  - Dependent upon community
- Full report: “Sustainable Energy storage Feasibility Study for Santa Fe Community College”, by Mark L. Bibeault and William L. Kubic Jr., LAUR-14-26026

What Was Our Approach?

- Energy Storage Technology Assessment
- Energy Storage Economic Assessment
- Size three site specific Modular Pumped Hydro designs for SFCC
  - Meets different community needs

- Energy Storage Technology Assessment
- Energy Storage Economic Assessment ← START
- Size three site specific Modular Pumped Hydro designs for SFCC

Examined Demand For Each Month of the Year…

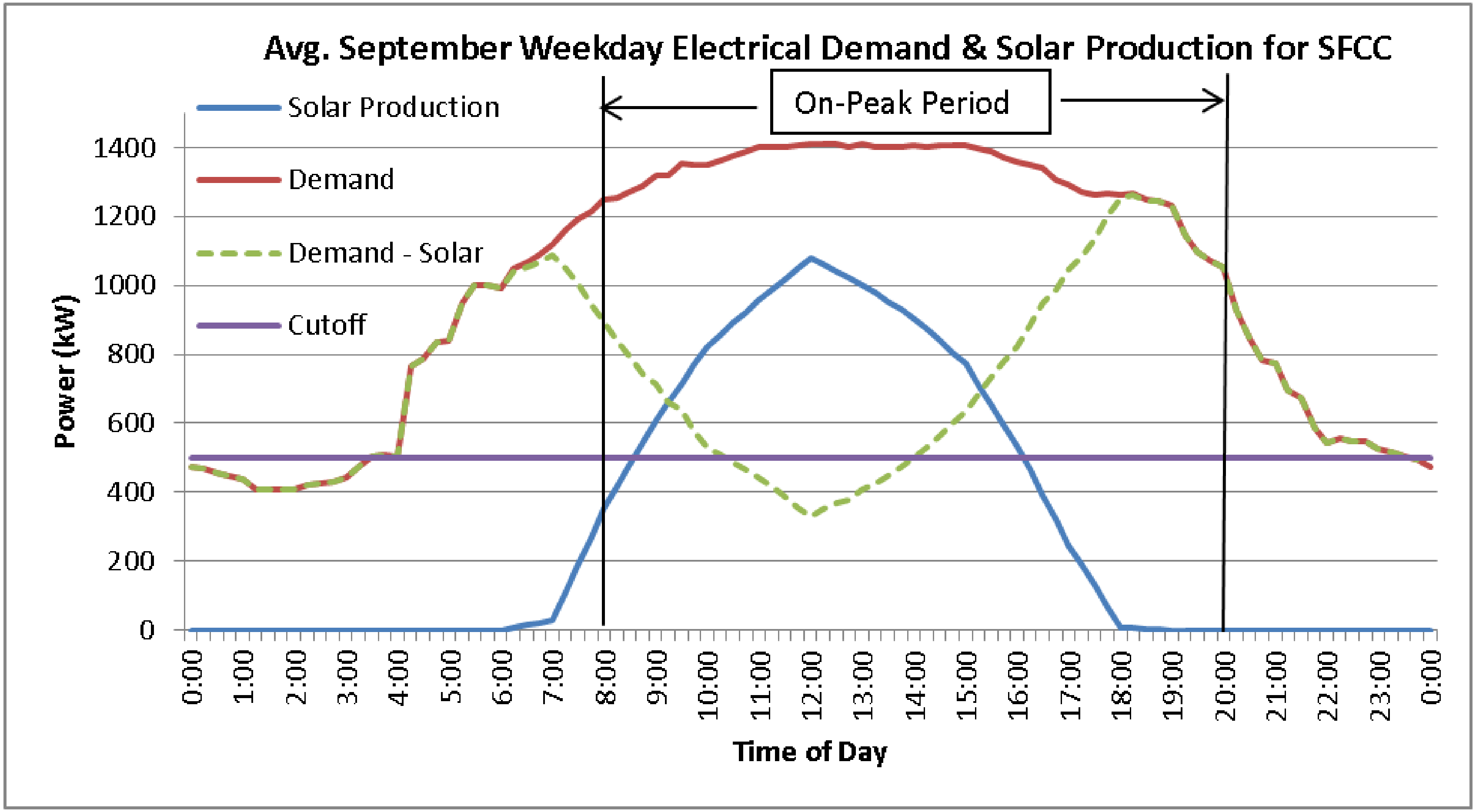
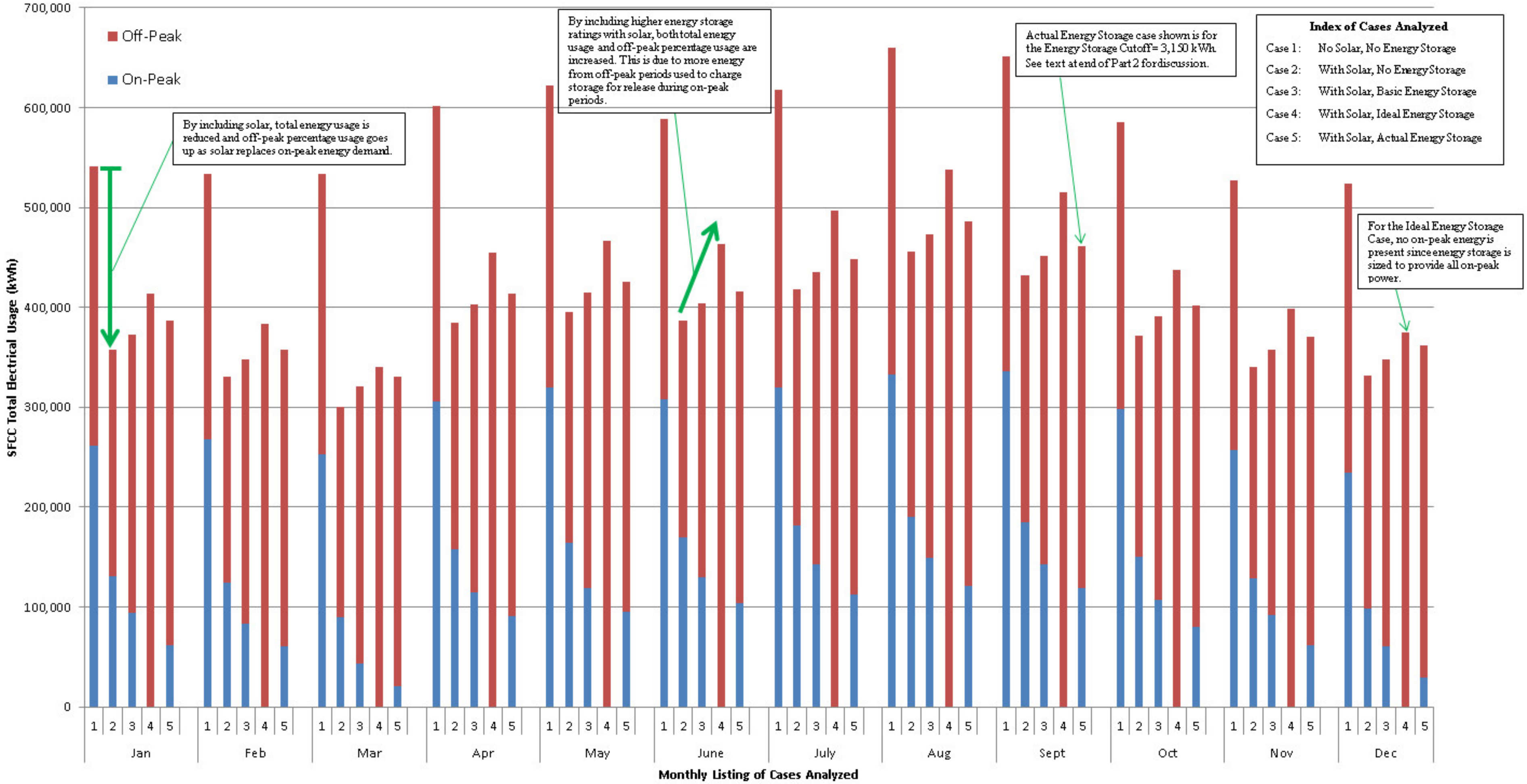
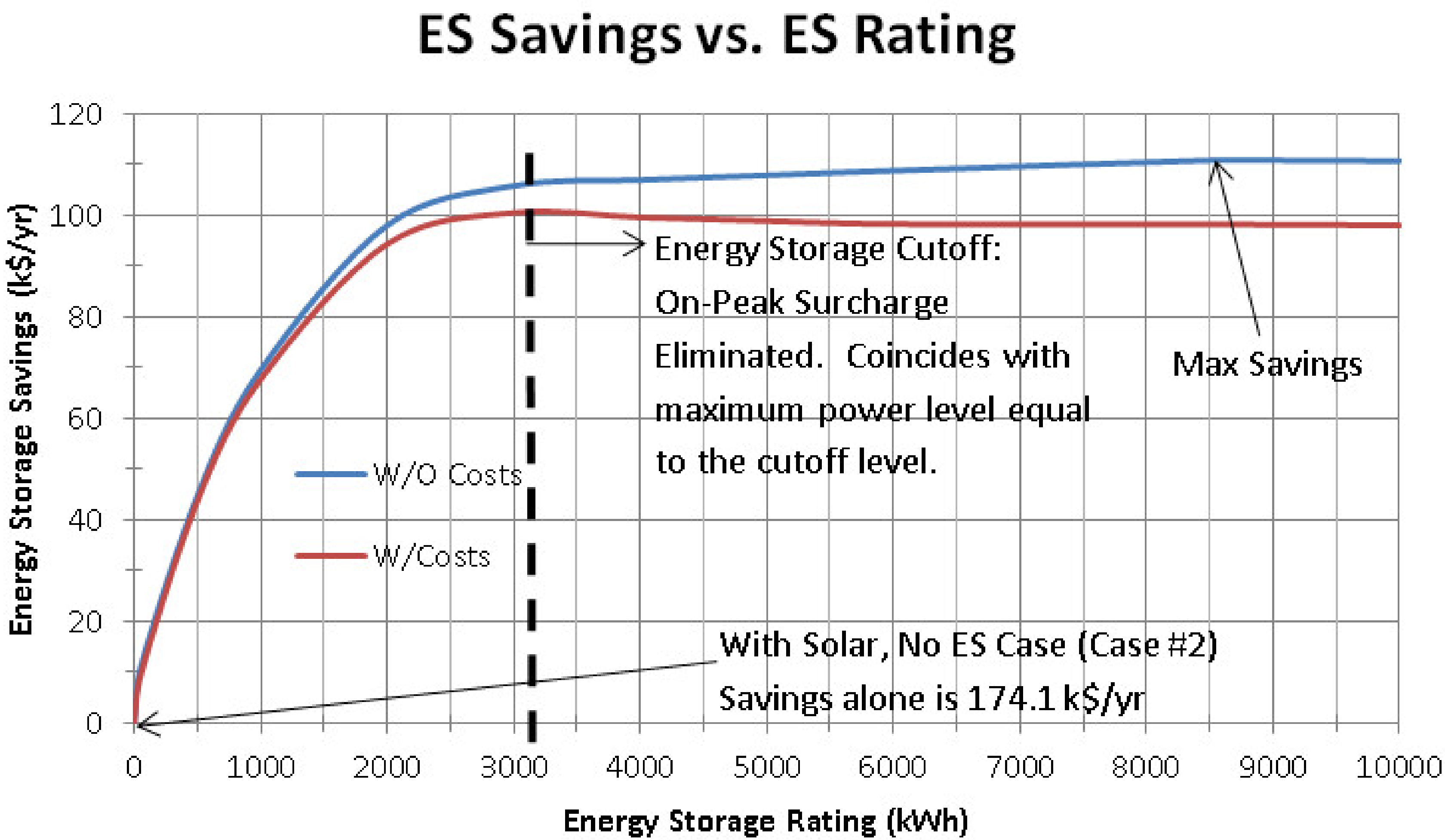


Fig A-6: Monthly Summary of SFCC Total Electrical Usage per Cases Analyzed for Year 2013

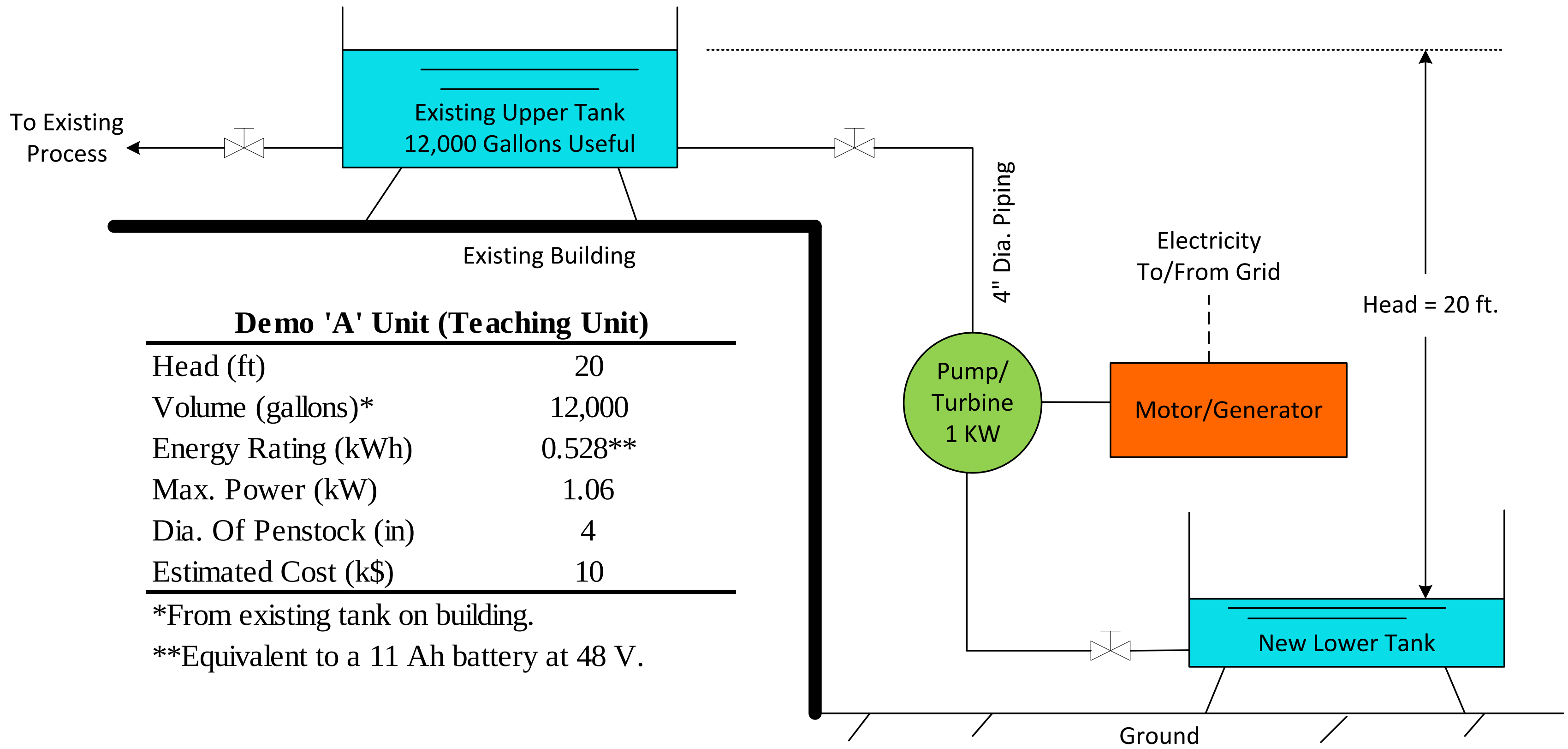



ES Savings vs. ES Rating
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Energy Storage Savings (k$/yr)
Energy Storage Rating (kWh)
W/O Costs
W/Costs
Energy Storage Cutoff:
On-Peak Surcharge
Eliminated. Coincides with
maximum power level equal
to the cutoff level.
Max Savings
With Solar, No ES Case (Case #2)
Savings alone is 174.1 k$/yr

- Energy Storage Technology Assessment
- Energy Storage Economic Assessment
- Size three site specific Modular Pumped Hydro designs for SFCC

Continue

Demo "A" Design Layout
The Teaching Unit



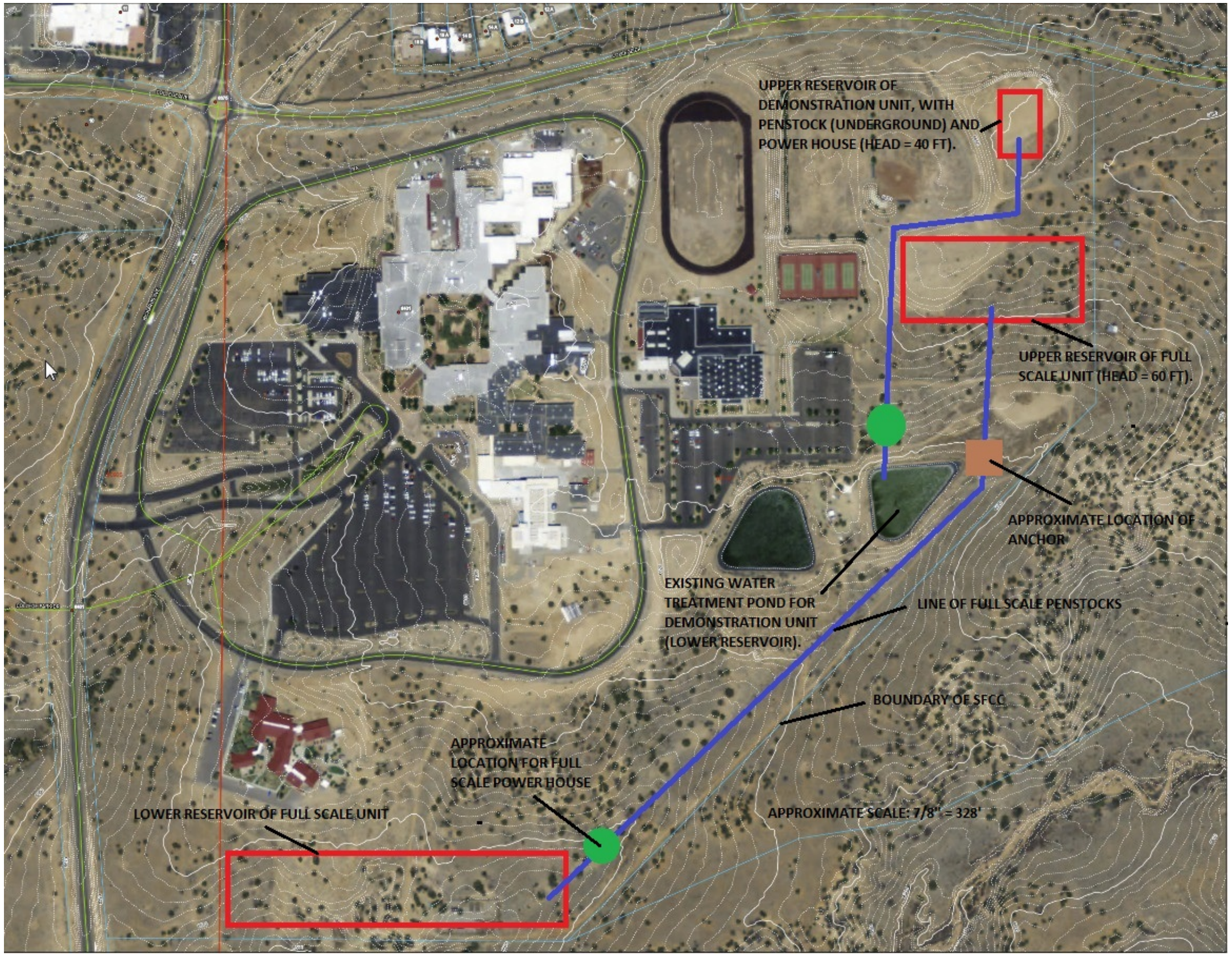
Demo 'A' Unit (Teaching Unit)

Head (ft)	20
Volume (gallons)*	12,000
Energy Rating (kWh)	0.528**
Max. Power (kW)	1.06
Dia. Of Penstock (in)	4
Estimated Cost (k$)	10

*From existing tank on building.

**Equivalent to a 11 Ah battery at 48 V.

Full-Scale and Demo "B" Units



Demo "B" Design Layout
Utilize Existing Water Infrastructure

Demo 'B' Unit

Design Parameter	Value
Head (ft)	40
Energy Storage Capacity (kWh)	57.4
Upper Pond Length (ft)	Approx. 150
Upper Pond Width (ft)	Approx. 150
Uppder Pond Depth (ft)	4
Upper Pond Surface Area (Acre)	0.52
Upper Pond Volume (acre-ft)	2.0
Max. Power (kW)	60
Penstock length (ft)	325
Diameter of Penstock (in)	12
Lower Pond Length (ft)*	Approx. 200
Lower Pond Width (ft)*	Approx. 200
Lower Pond Depth (ft)*	5
Lower Pond Surface Area (Acre)*	0.66
Lower Pond Volume (acre-ft)*	2.9
Estimated Initial Fill Duration (Days)	0

*Lower pond is existing water treatment pond.

Full-Scale Design Layout
Sized to Energy Storage Cutoff Level

Full Scale Unit

Design Parameter	Value
Head (ft)	60
Energy Storage Capacity (kWh)	3,150
Upper Pond Length (ft)	250
Upper Pond Width (ft)	320
Uppder Pond Depth (ft)	30
Upper Pond Surface Area (Acre)	2.70
Upper Pond Volume (acre-ft)	61.3
Max. Power (kW)	760
Penstock length (ft)	2300
Diameter of Penstock (in)	30
Lower Pond Length (ft)	320
Lower Pond Width (ft)	250
Upper Pond Depth (ft)	30
Lower Pond Surface Area (Acre)	2.70
Lower Pond Volume (acre-ft)	65.7
Estimated Initial Fill Duration (days)**	471.0

**Assuming 50k gpd and 110% of lower pond vol.

MPH Considerations…

- How can be utilized in your community?
- How can this be apart of my career?
  - Not only technical. Collaborative Teams!
- How can this be a teaching tool?
- How to finance such an undertaking?
  - Documentary movie
  - Crowd Sourcing

Community Qualify of Life Considerations In Regards to MPH…..

- Land use?
- Water use?
- Better energy management?
- Incentives to change peoples behavior?

From the Beginning - Why Energy Storage?
To Enhance Qualify of Life In Our Communities!

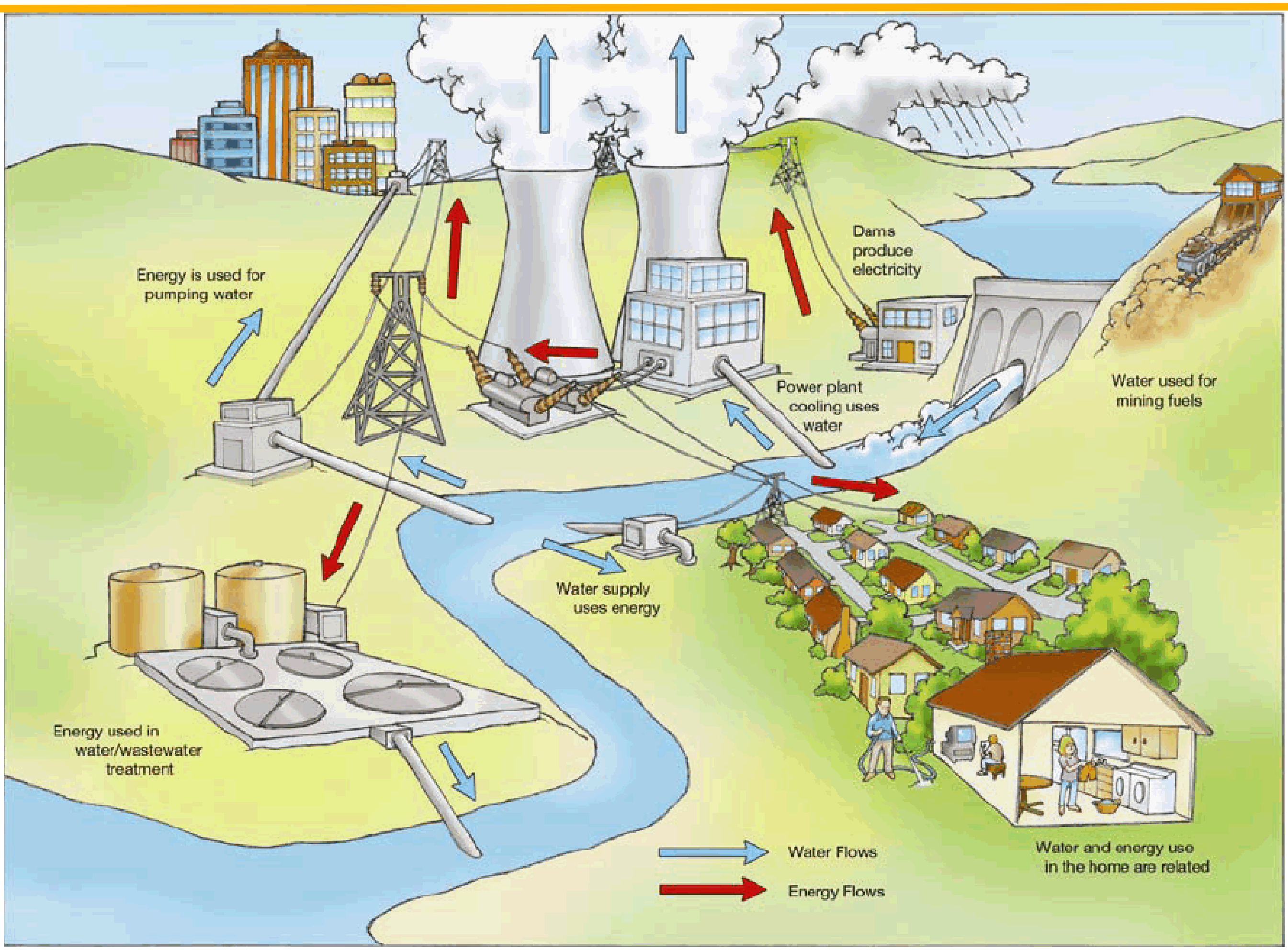
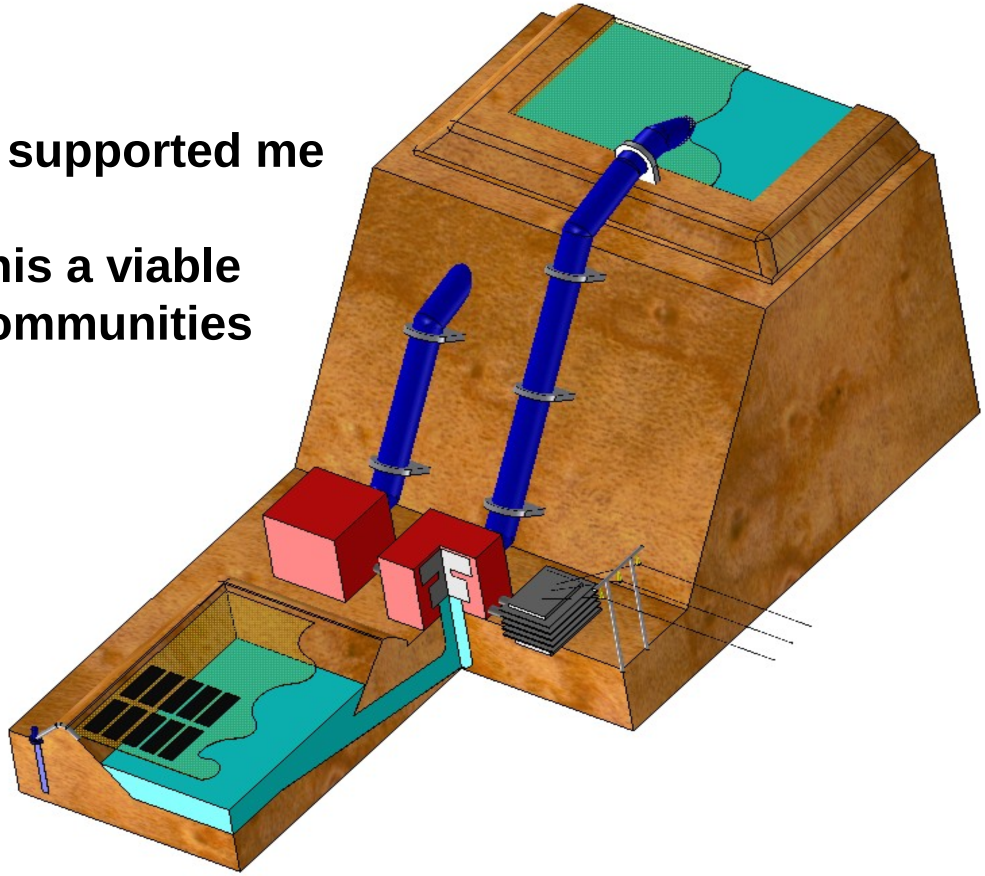


Figure I-1 of “Energy Demands on Water Resources, A Report to Congress”, US DOE, December 2006.

Modular Pumped Hydro(MPH)
Rethinking the Possibilities

- **Many people have supported me**
- **We want to offer this a viable option for many communities**
- **Thank you!**
- **Any Questions?**



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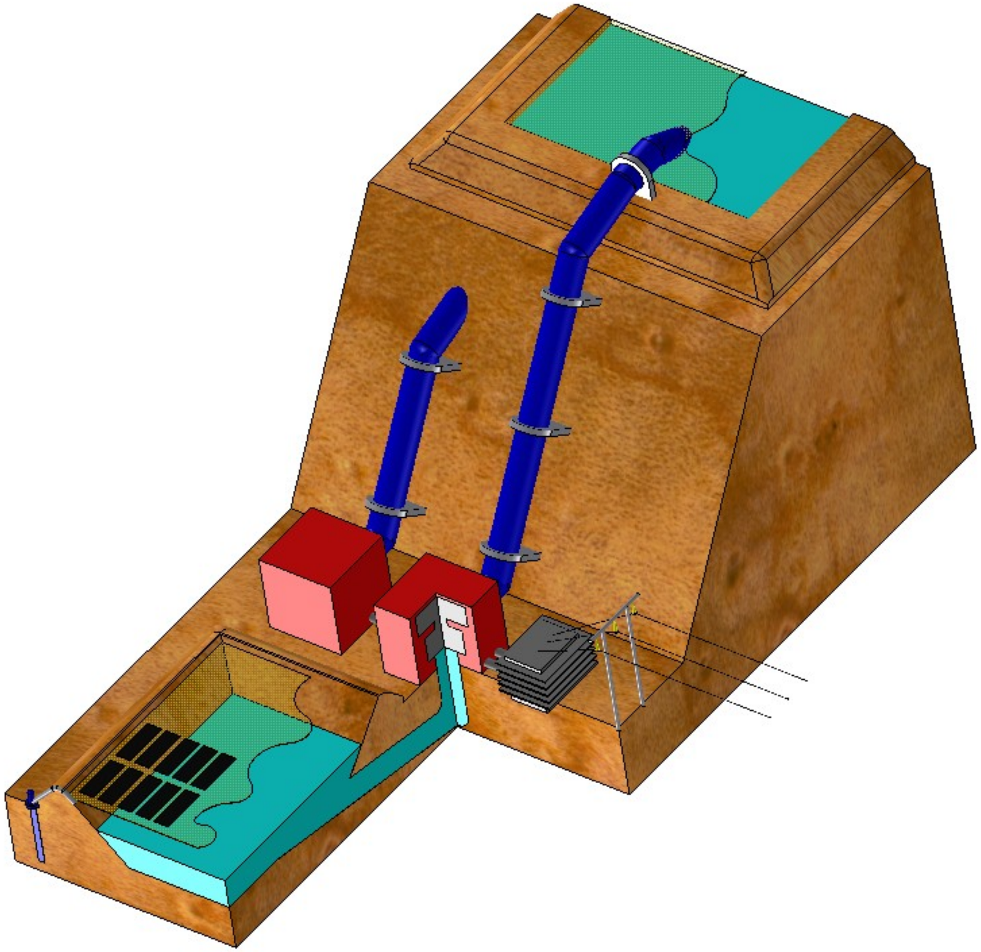
Reference Slides Follow



The Holes That We Dig and Must Fill (World #'s).
(It's Mind Boggling!)

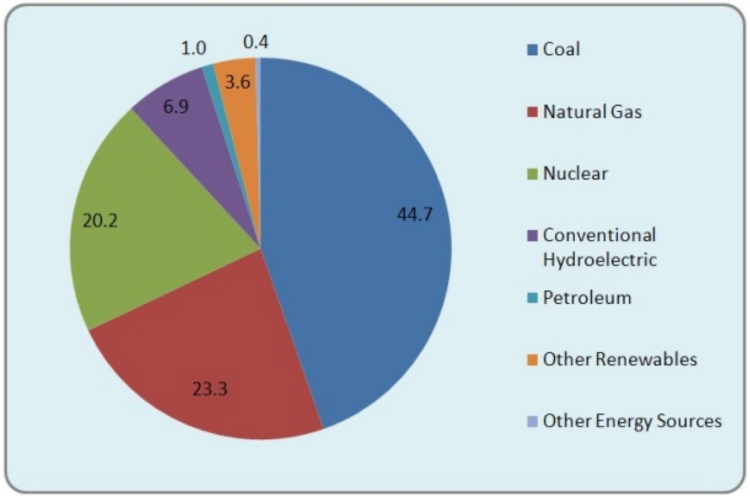
- OIL: 85 million barrels/day
- NATURAL GAS: 260 billion cubic feet/day
- Coal: 14 million tons/day

- OIL: 1.1 × 1.1 × 1.1 cubic miles per year
- As liquid: 1.3 × 1.3 × 1.3 cubic miles per year
- COAL: 1.0 × 1.0 × 1.0 cubic miles per year

Slide 16 of presentation "Will There be Enough Energy for All in the 21'st Century", LA-UR-06-2989, 2006, by Rajan Gupta.

Total US Fuel (Electric Gen) and Water Usage (More Mind Boggling)

% Net US Fuel Consumption (2009) Electric Generation



US Energy Information Administration/Electric Power Monthly, March 2010, Table ES1.B for 2009, for all sectors.

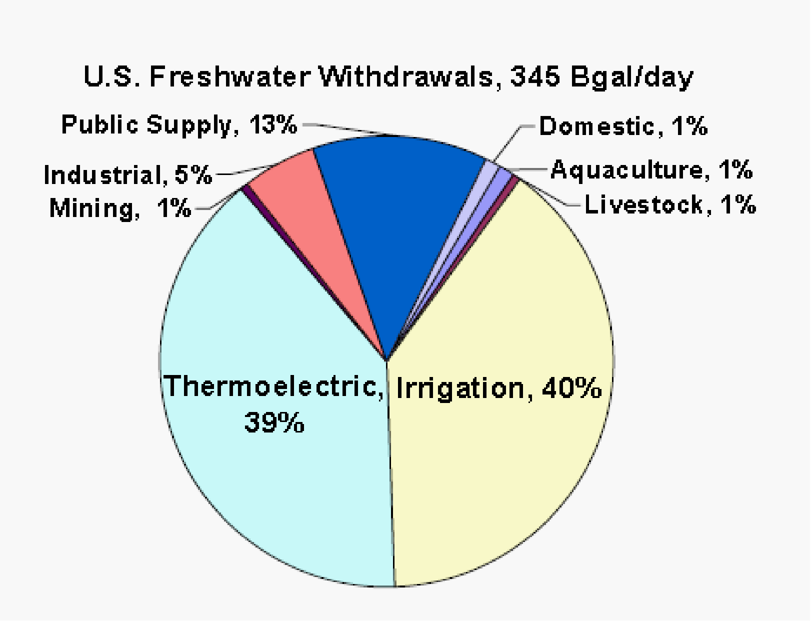
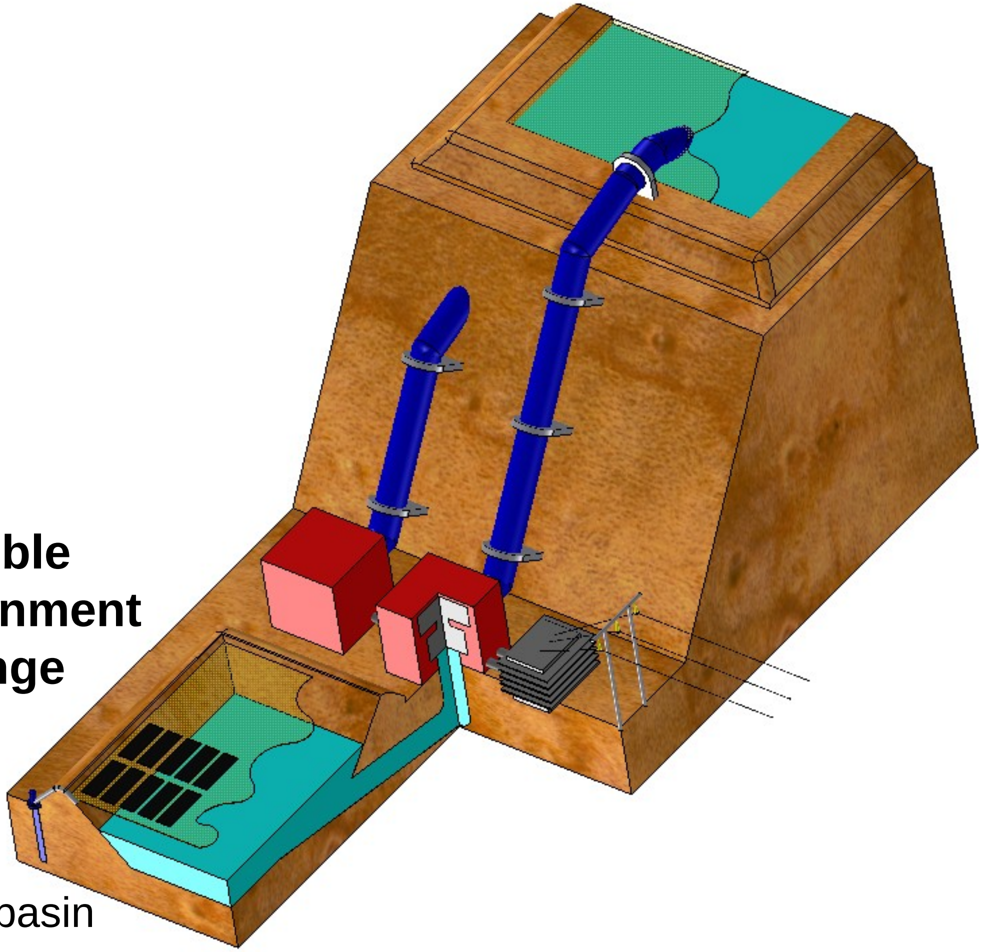


Figure II-1 of “Energy Demands on Water Resources, A Report to Congress”, US DOE, December 2006.

3.95 x 10^9 MW-hrs across all sectors

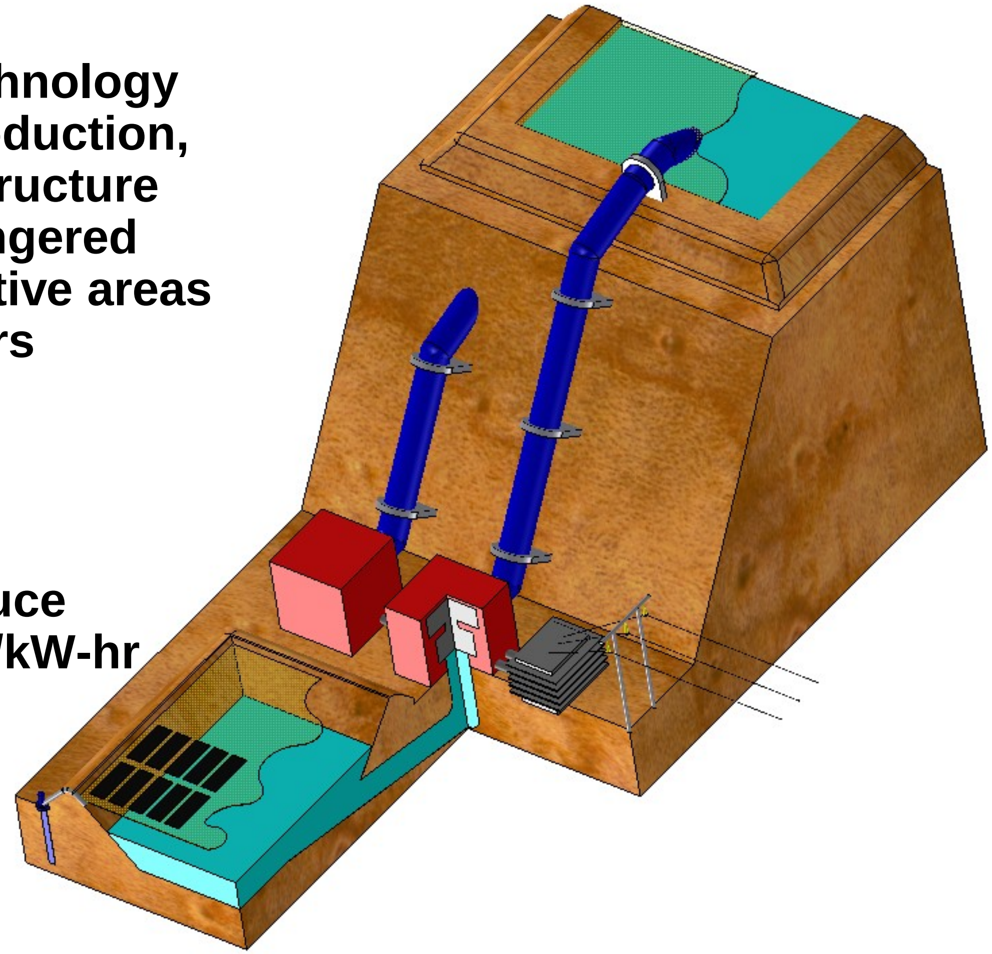
Why is MPH Different Than Conventional Pumped Hydro? Design Philosophy – In General

- **Modular size enables design**
- **Ring embankment, earth fill**
- **Reservoirs covered & lined**
- **Leakage recycled**
- **Catch rainfall**
- **Complimentary solar siting**
- **20 to 300 m head**
- **0.5 to 300 MW power rating**
- **Up to 12 hrs discharge**
- **Build above ground where feasible**
- **Minimize effects on local environment**
- **Coatings allow water quality range**
- **Per reservoir**
  - Approx. 1000 acre-ft volume
  - Approx. 10 acres surface area
  - Located flat top mountain with flat basin



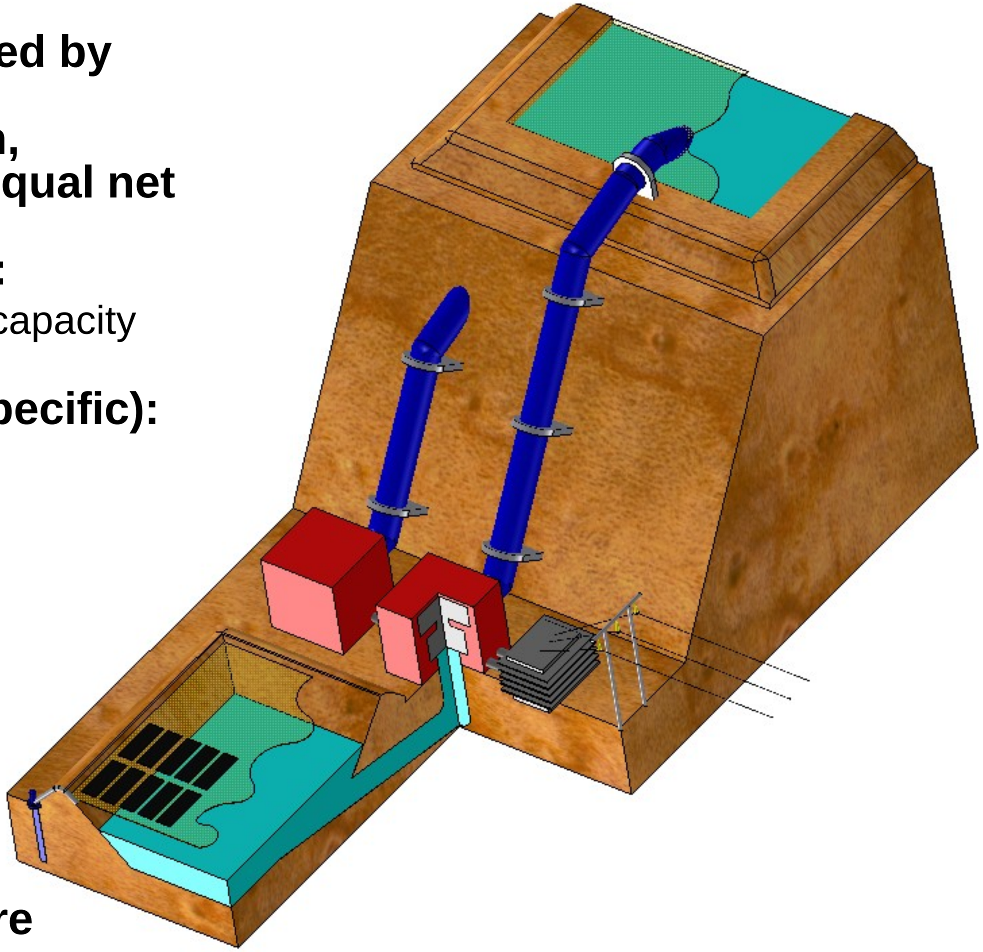
Why MPH?
Operations – In General

- Up to 1 GW-hr electric storage
- Closed-loop pumped hydro technology
- "Smart-Sited" near existing production, transmission, and water infrastructure
- "Smart-Sited" away from endangered species, environmentally sensitive areas
- Permit/Build/Commission < 4 yrs
- Total Cost < 2 $/W
- "Black Start" capability
- Emergency backup capability
- Depending upon configuration, simultaneously store and produce
- Total Operating Cost < 10 mills/kW-hr
- < 1 minute zero to full power
- < 10 minutes max. storage rate to max. production rate



Modular Pumped Hydro(MPH) Water Management Examples

- **Evaporation controlled by cover**
- **Seepage and permeation controlled by liner**
- **Sum of rainfall minus evaporation, seepage and permeation losses equal net zero over life of facility**
- **System charge duration (flexible):**
  - 18 – 24 months (< 2 acre-ft/day) full capacity
  - > 24 months with delayed capacity
- **Fresh to brackish sources (site specific):**
  - Rainfall
  - Groundwater
  - Surface (temporary flumes/pumps)
- **Periodic maintenance:**
  - Aerate using solar energy
  - Remove settled out solids
  - Remove weeds mechanically
  - Vacuum covers



- **Opportunities to integrate with existing municipality infrastructure**