D-Lab: Energy

Week 2: Energy Storage & Trip Introduction

AGENDA

- Where are we?
- Muddy Card Review
- Human Power Review
- Energy Storage & Micro Grids
- Trip Plan
- Reading discussion
- Homework
- Muddy Card

Week	Class	Lab
Feb 2	Introduction: Energy, Units, Esti-mation, Energy Usage Worldwide, Class Overview	Human Power Lab
Feb 9	Energy Storage & Micro Grids Initial Trip Planning	Energy Storage Lab
Feb 16	Lighting Community Partner Introduction	Biogas & biodiesel lecture & construction
Feb 23	Solar Thermal & PV **Quiz I**	Solar Panel Construction, Installation, and Operation
Mar 2	Wind & Micro-Hydro Trip Planning	Savonius Wind Turbine Construction & Testing
Mar 9	Cooking, Stoves, & Fuel Biogas digester testing	Charcoal Making & Stove Testing
Mar 16	**Trip Plan Presentations** **Quiz II**	Trip Prep
Mar 23	Trip	Travel, Learn, Apply

Muddy Cards!


ke.com

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See lecture video.

WATER: TUMP LINE / NAMLO

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See lecture video.

HEAD CARRY
(GETTING HELP LOADING / UNLOADING IS NORMAL)

Pedal Power in Transportation

Several slides removed due to copyright restrictions.
See lecture video.

Pedal Power in Work: Pedal-Powered Machines

THE PROBLEM WITH POWER

POWER GRIDS
&
ENERGY STORAGE

Images removed due to copyright restrictions.
"Visualizing the U.S. Electic Grid." *NPR*. May 1, 2009.
See lecture video for discussion of this content.

http://www.npr.org/templates/story/story.php?storyId=110997398

JUMPER CABLE SCENARIO

- 400 Amps
- 12 V
- AWG 26: 0.01594" diameter
- AWG 4: 0.20431" diameter
- copper resistivity: 1.724x10^-8 ohm-m @ 20 deg. C
- *what length cable can be used for each AWG?*

MICROGRIDS

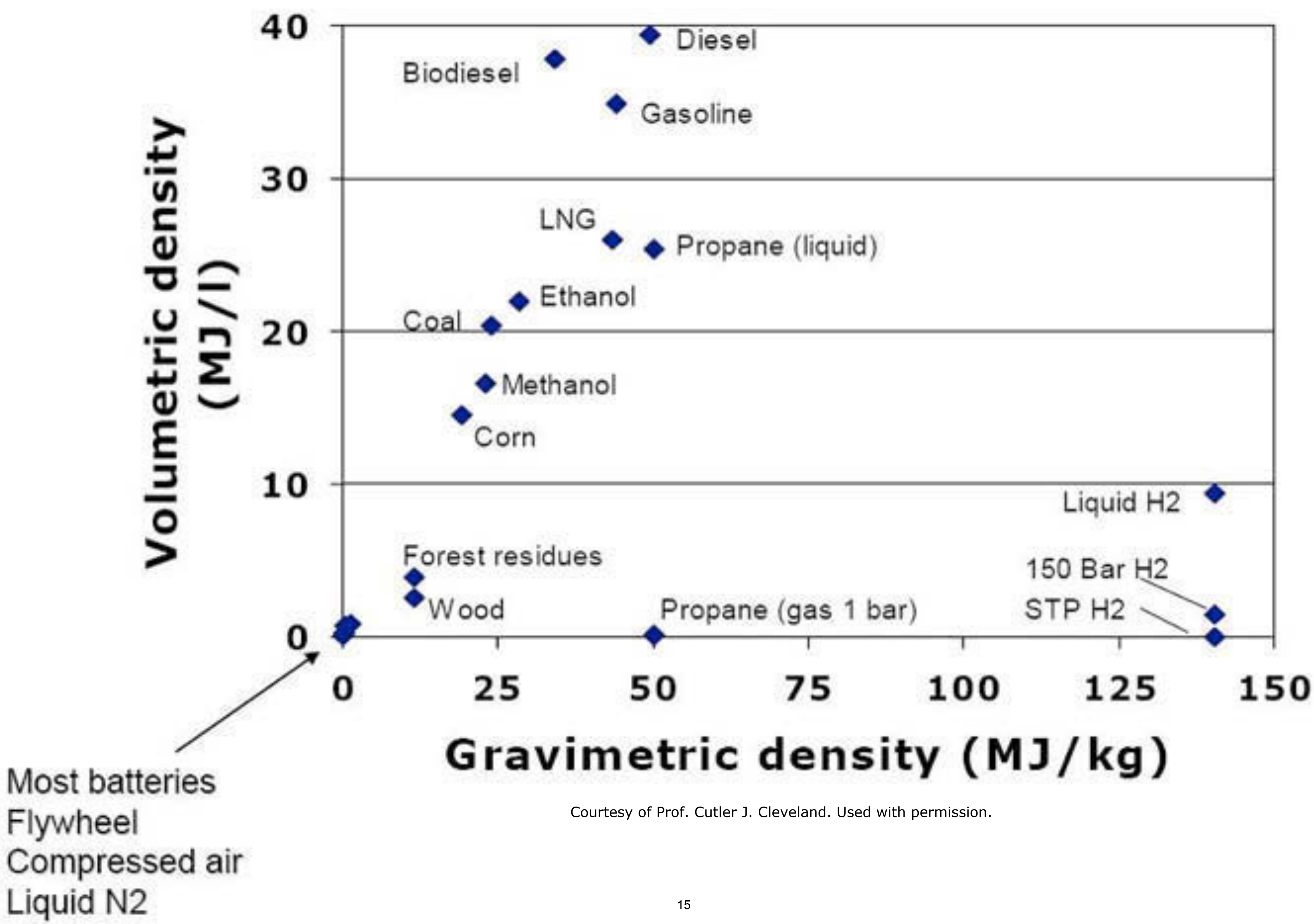
Benefits

- autonomy
- compatibility
- flexibility
- scalability

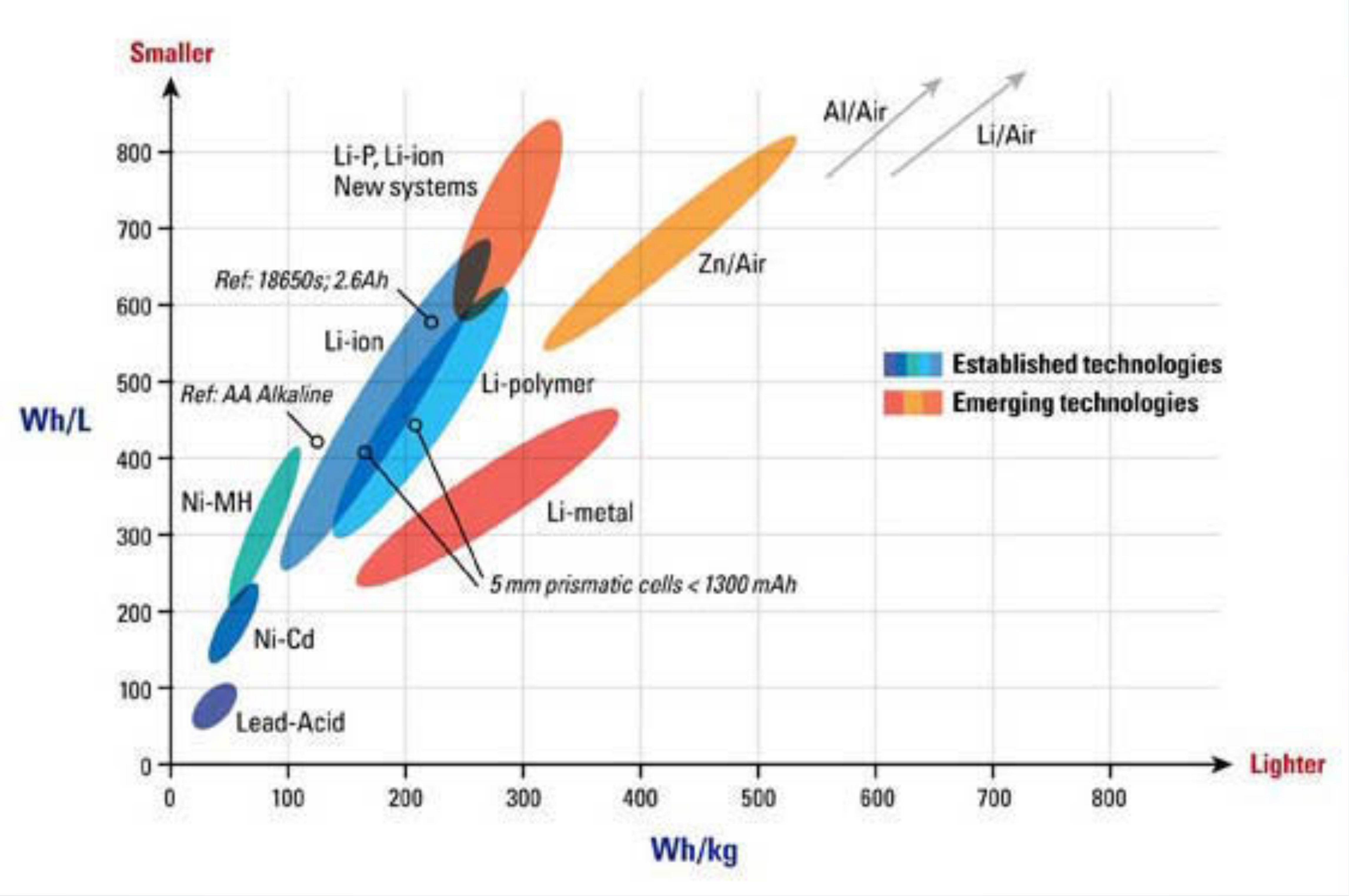
Challenges

- maintenance
- limiting loads
- private vs. public sector

Energy Density



Courtesy of Prof. Cutler J. Cleveland. Used with permission.


Smaller
Wh/L
800
700
600
500
400
300
200
100
0
Li-P, Li-ion
New systems
Al/Air
Li/Air
Zn/Air
Ref: 18650s; 2.6Ah
Li-ion
Li-polymer
Ref: AA Alkaline
Established technologies
Emerging technologies
Ni-MH
Li-metal
5 mm prismatic cells < 1300 mAh
Ni-Cd
Lead-Acid
0
100
200
300
400
500
600
700
800
Lighter
Wh/kg

EXCELLENT BATTERY RESOURCE

http://web.mit.edu/2.009/www/resources/mediaAndArticles/batteriesPrimer.pdf

BATTERY CONSIDERATIONS

- Physical characteristics: size, shape weight
- Voltage: nominal, maximum, minimum, discharge profile
- Load current: rate, constant power, constant resistance, pulsed
- Duty cycle: continuous, intermittent, cyclic
- Charge/discharge cycle: cycling (float), deep cycle, efficiency of charging
- Temperature range: maximum, minimum and nominal
- Service life: required operation time
- Safety: failure rates, leakage, off-gassing, toxicity, disposal
- Environment: vibration, acceleration, orientation
- Maintenance: regular upkeep, replacement
- Cost: initial, life-cycle

(c) David Wallace, http://web.mit.edu/2.009/www/resources/mediaAndArticles/batteriesPrimer.pdf

SIZING BATTERIES

1. Determine energy source daily average, as well as daily and seasonal variation
2. Determine load daily average, as well as daily and seasonal variation
3. Required days of storage (autonomy)
   3.1. typically 3-6 days, depending on daily and seasonal source & load & variation
4. Iterate given budget

DC Energy Source

Charge Controller
98% efficient

Battery
(never below 20%)

Inverter (DC to AC)
75% efficient

Load (AC)

ESTIMATIONS

1. Power for typical objects
   i. Light
   ii. Tv
   iii. Computer
   iv. Car
   v. Motorcycle
   vi. Fridge
   vii. Oven
   viii. Radio

2. personal daily energy consumption (turn in)

D-Lab: Energy

Public domain image (source: US CIA).

Next Lab: Energy Storage
Next Class: Lighting (& community partner intro.)

SPRING BREAK TRIP

- Spring break: March 19-26 (approximate)
- Cost for you: $500 + medical, passport/visa, food, & gifts
- DO NOW
  - fill out form online (posted tonight or tomorrow)
  - check passport expiration & visa requirements
  - make MIT Medical travel clinic appointment for vaccines
  - be prepared to commit to trip/class on Friday
  - review packing list (posted tonight or tomorrow)

ENERGY READING DISCUSSION

Practical Action. *Poor People's Energy Outlook 2010.*
http://practicalaction.org/ppeo2010

PSET 2: PERSONAL ENERGY CONSUMPTION CHALLENGE

Determine your total energy used on a given day and average power consumption.

Choose two days over the following week.

Day 1: consider only consumables (you do not need to worry about the energy required to make the laptop, etc., just the energy you consumed using it), document the energy you used. Possibilities: food, cooking, water, lighting, electricity for laptops/computer/cellphone/other appliances and technology, heating/cooling, transportation).

You'll need to do a lot of estimating here; that's to be expected, just document how you arrive at your numbers. For a shared situation (for example, taking a public bus with 10 other people), you can divide to calculate your portion.

Estimate/calculate the total energy consumed by your life (daily), and calculate your average power usage.

What percentage of your daily energy consumption is in your control? What is out of your control (for example, in most dorms and classrooms you have NO control over the temperature)? What is a grey area (for example, you can choose which computing device to use to do your work, but you can't eliminate use of a computer entirely if you want to pass your classes)?

PSET 2: PERSONAL ENERGY CONSUMPTION CHALLENGE

Day 2:

Make a list of the areas where you think you can cut back, and by how much. Strive to cut back aggressively ... cutting back by 1% is not sufficient.

Implement your cutbacks for one day and calculate how close you were to your estimate in part a.

Write about the experience: how hard was it to cut back? Discuss how close you were to your target and if you were off, how and why. Where else would you have liked to cut back but couldn't, and why not? Other reflections on the experience.

If you were forced to use 10% of the energy you currently estimate you're using, what would you do? Where does that 10% goal come from? You may recall from week 1 that in the US our average annual energy usage per capita is 360 GJ, whereas in Nicaragua it's 25 and in Haiti it's 11.

OTHER: plastic bottles & Spanish podcasts

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