# Field Power Using Harvested-Energy Sources

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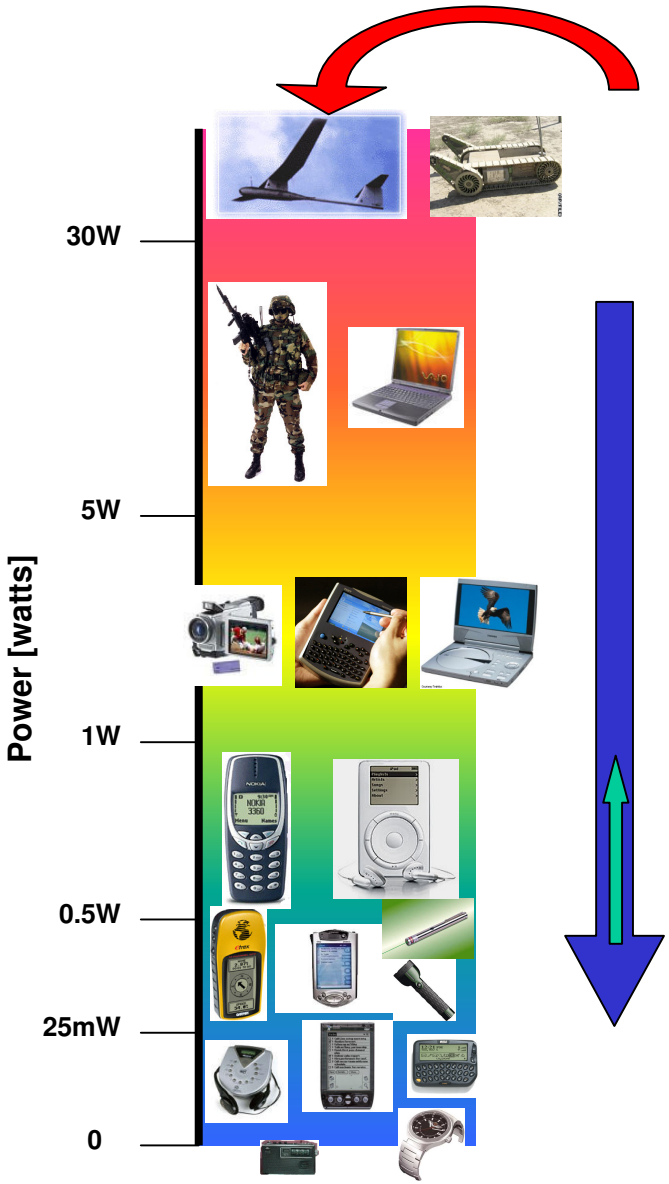
# Intro

- Portable Electronics Power Requirements
- Recent Developments in Energy-Harvesting
- Incorporating It Into Ongoing Operations
- Future Developments to Watch For

# Power Requirements

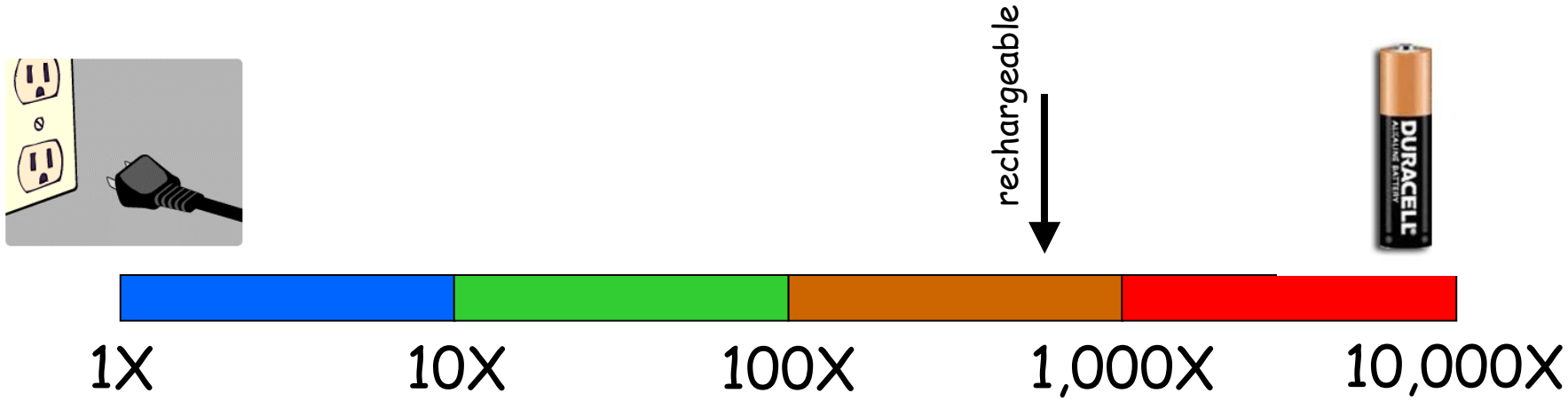



Stationary Devices
Achieve Mobility

Power Improvements
Over Time

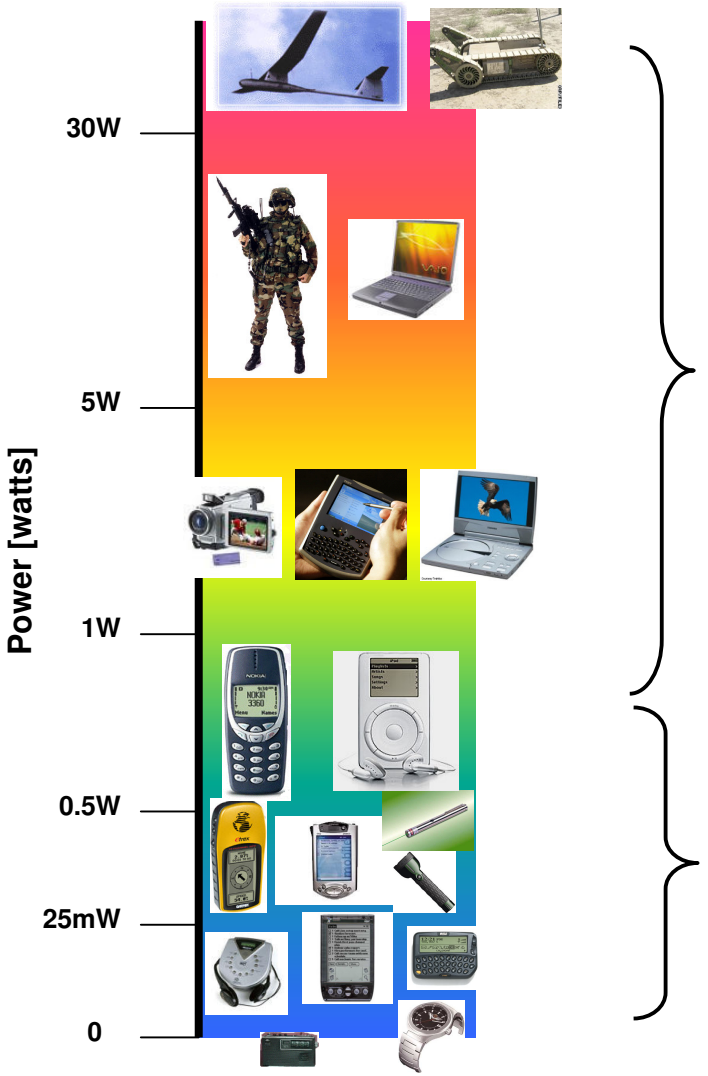
(- added functionality)

# Primary Batteries Are Expensive

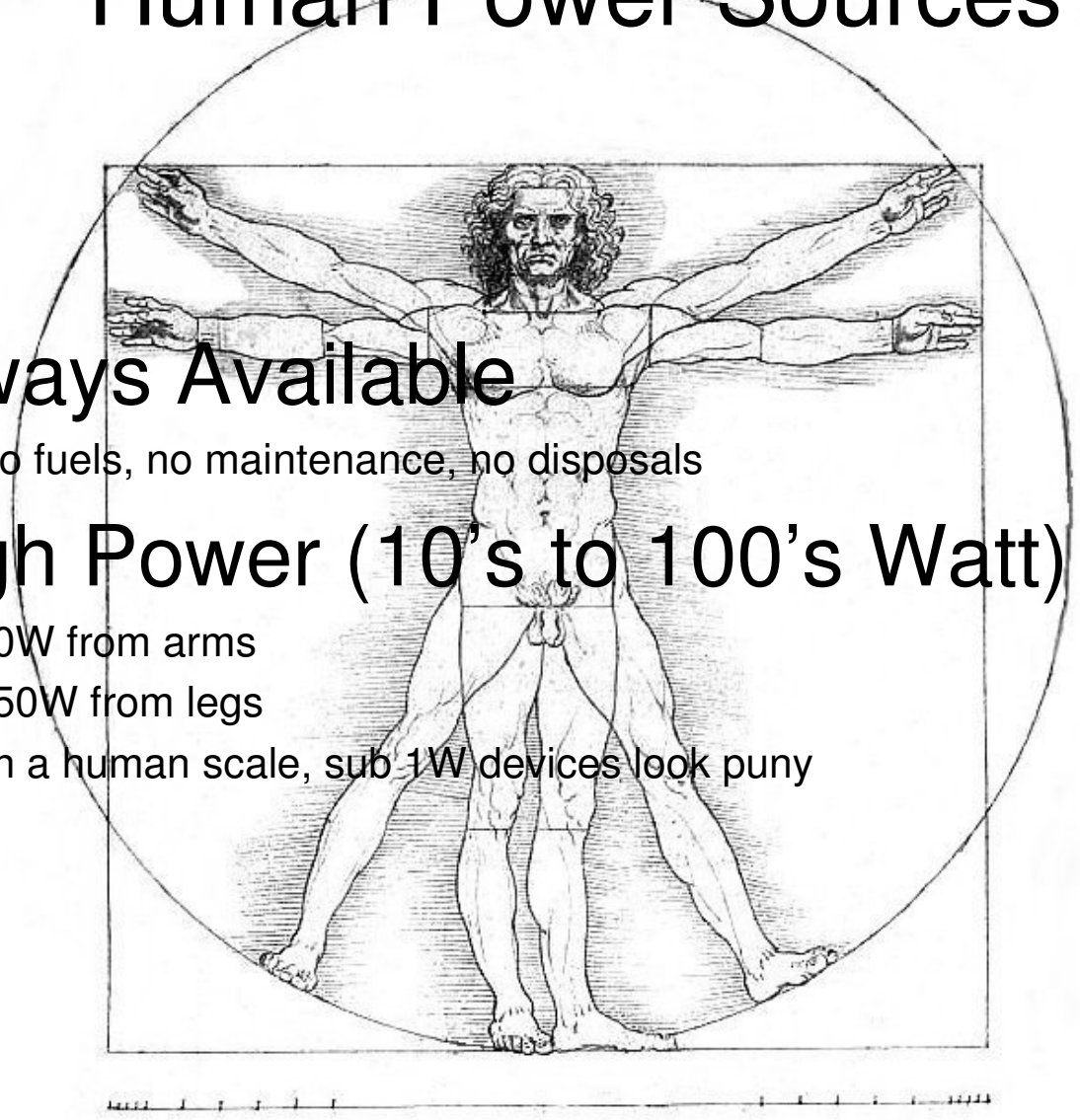



- Toxic Disposal
- Heavy to Carry
- Logistics Burden
- Primaries have advantages, being cheap is not one of them

# Batteries: Primaries vs. Rechargeables

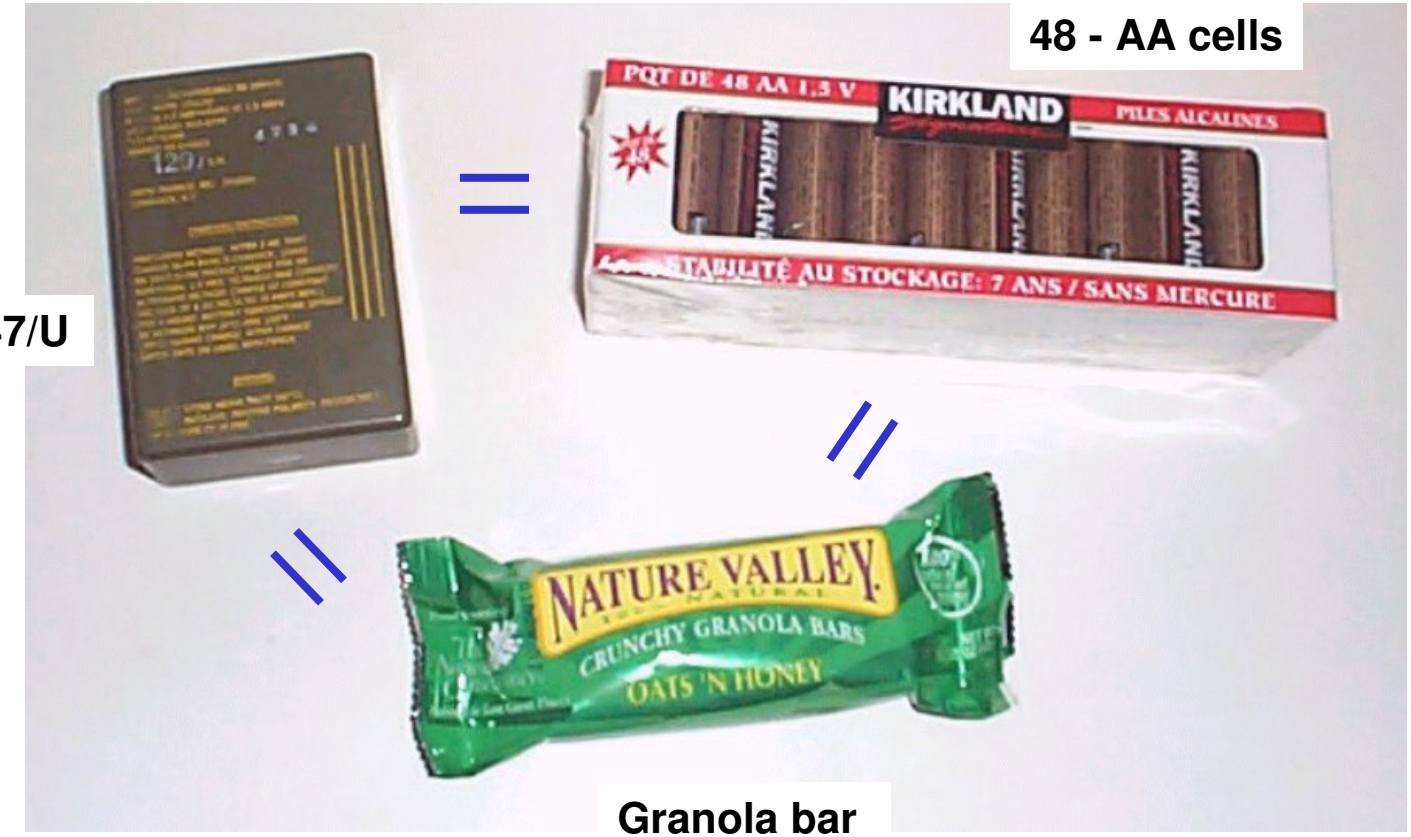



# Human Power Sources



- Always Available
  - No fuels, no maintenance, no disposals
- High Power (10's to 100's Watt)
  - 20W from arms
  - 150W from legs
  - on a human scale, sub 1W devices look puny

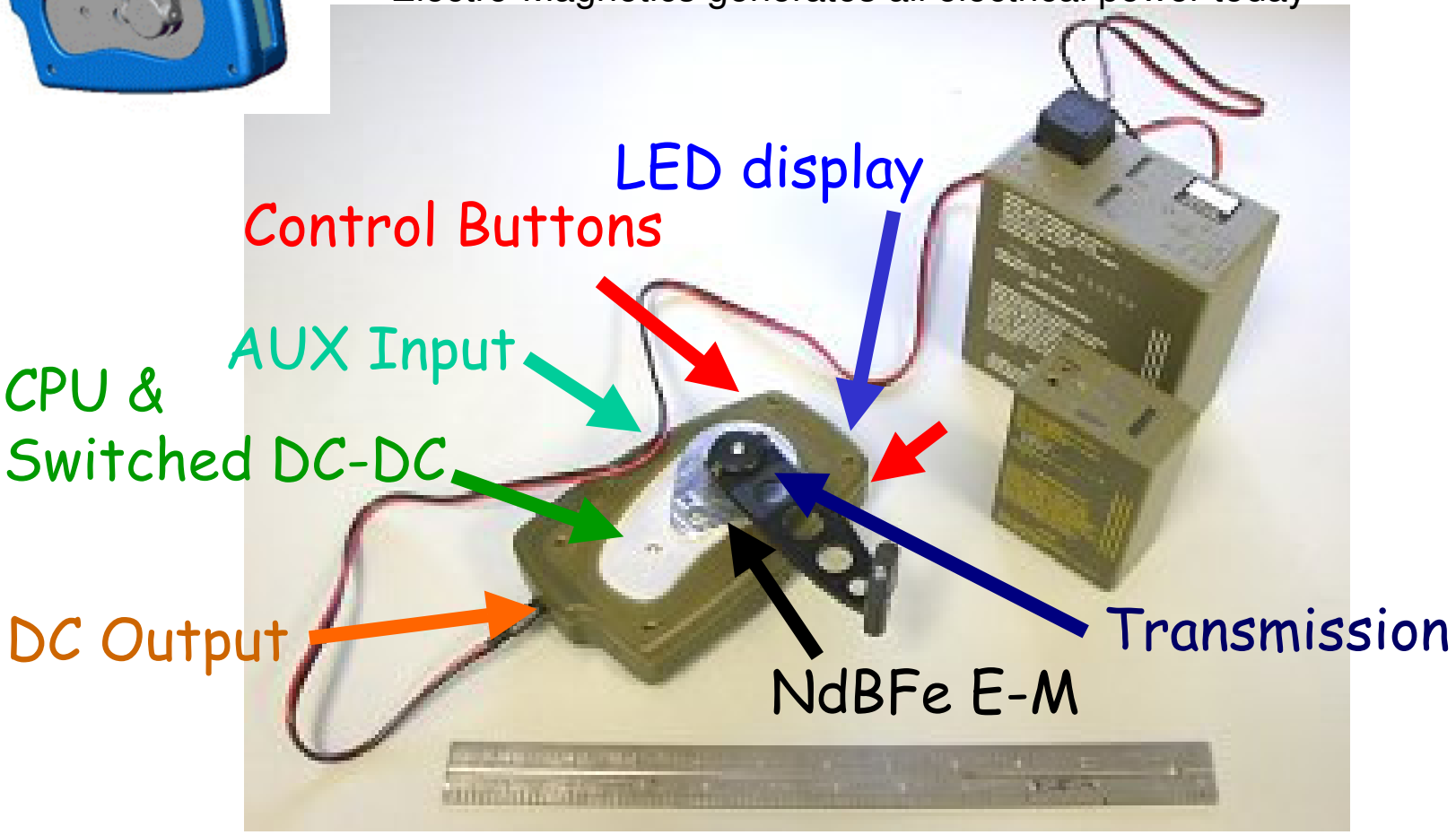
# Energy Sources




**1 food calorie = 1.16 watt-hour = 1 AA battery**

# System Overview

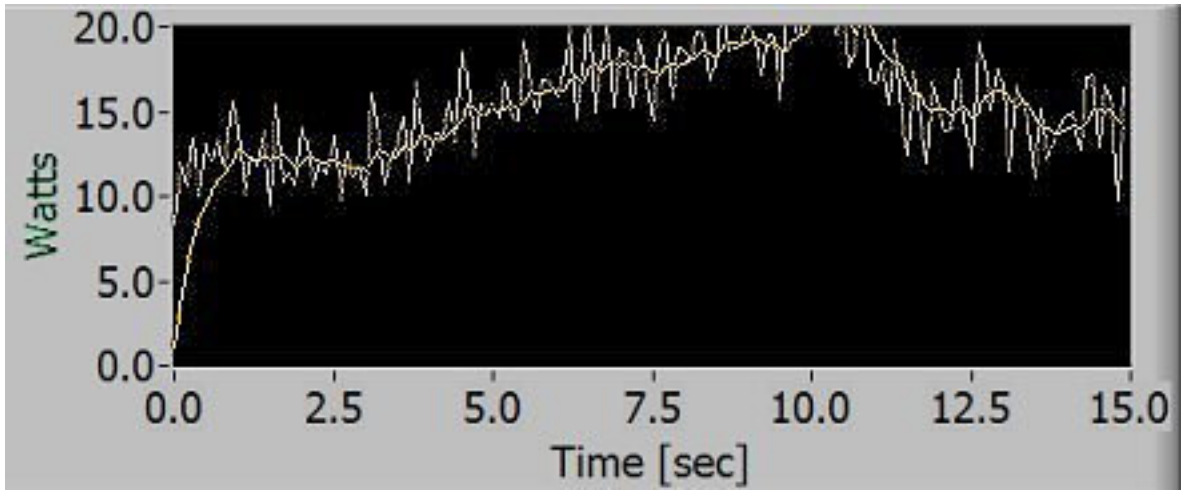
- Modern version of old idea
- Electro-Magnetics generates all electrical power today




- Field-programmable

# Usage Lessons Learned

- Human Energy
  - Power Limited By Humans - Not Technology
  - Fatigue, Non-Constant, Person-to-person variance, 2-15 mins attention span
  - Force Not Power
- Ergonomics - “Gear Change” Gives 50% Power Boost
  - Need Selectable Special Torque-Speed Profiles (not in prior art designs)
  - Output Power is High, need controls with high rate charging
- Limited User Knowledge
  - User interface & automatic operation determination



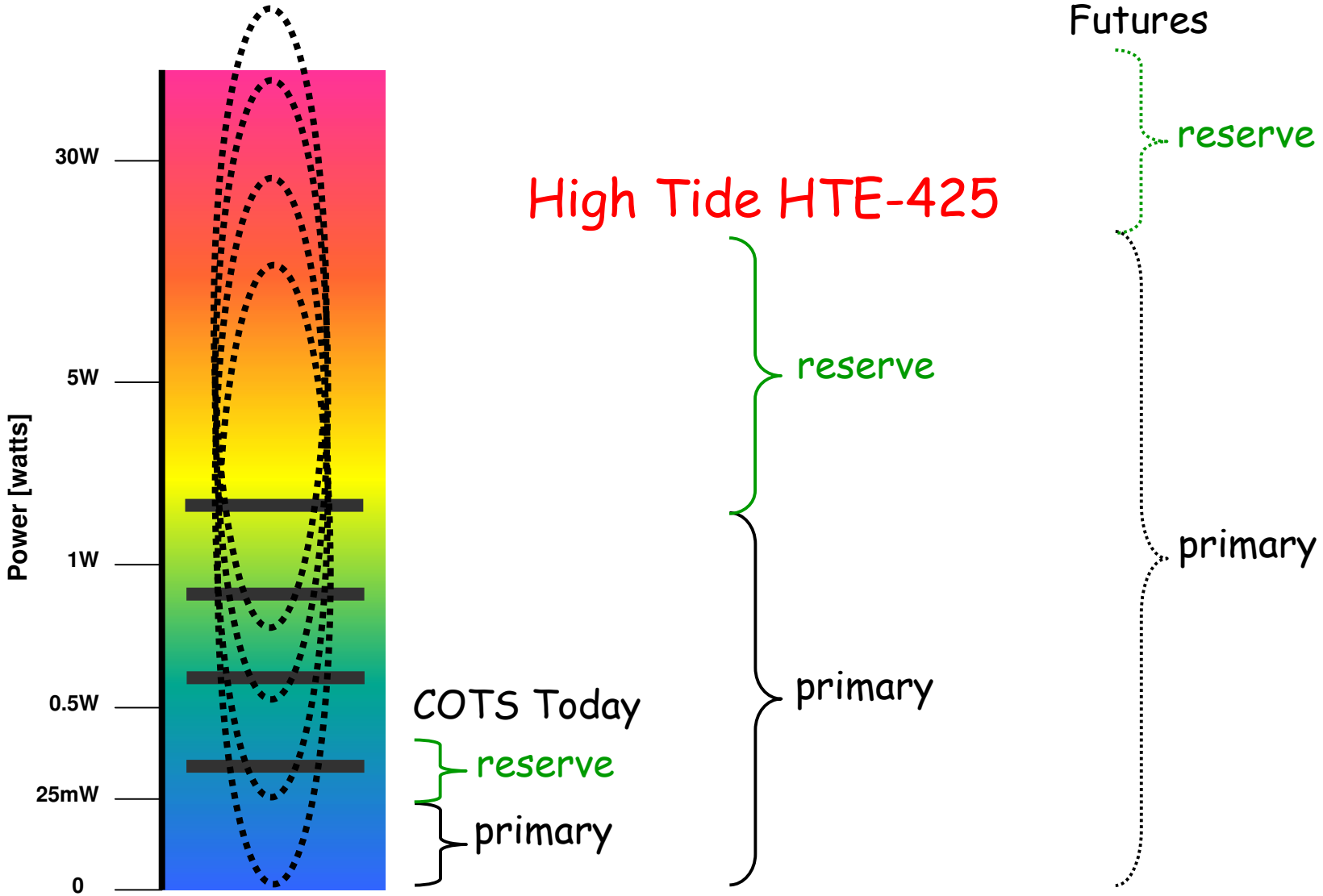
# Mobile Power Technology Integration

- Many Devices volts/amps, Needs Change Mission to Mission
- Multiple Power Sources - Need Interoperability
  - Legacy batteries (primary/secondary),
  - New batteries-Smartbattery (also w/built-in charge controllers)
  - Tactical Generators, AC-DC

# Mobile Power Trends

- New Power Sources Are Hybrid: Combined w/ Rechargeable Batteries
  - Fueled
    - Fuel Cells: low power output, combine with rechargeables
    - Miniature ICE Generators: one running speed, combine with rechargeables
  - Non-Fueled
    - Solar: needs sunlight, combine w/rechargeables
    - Human Energy: varying high power, buffer w/rechargeables
- New High Charge Rate Battery Chemistries Emerging
  - Fewer spares needed
  - Rayovac, Toshiba, a123systems, protogenix, NEC, Altair
- Higher Mobility Tactics
  - Adopt lighter, more power efficient electronics
  - Carry req'd energy, use field-harvested electricity for unplanned needs
- Be Flexible, Keep Options Open

# Energy Harvesting Feasibility



# Conclusions

- Scenarios
  - Soldier Effectiveness depends on mobile electronics
  - Self-reliance: just what you carry, find in the field, reduce total weight
  - Innovate & adapt to changing conditions: eqp failures, logistics, unforseen events, poor infrastructure
- Human + E-M Energy Harvesting
  - High wattage drives all current & future mobile electronics devices
  - Flexible output charges all battery chemistries & directly drives devices
  - Ideal for emergency use – rugged, no fuels, no maintenance, no disposal, long shelf life
- Power Forecast
  - Integrate multiple sources: One size does not fit all. Not now, not in the future
  - Improving E-M designs & materials - Ever Higher Human-Power Levels
  - New electronic devices, Reduced power draws, Rapid-charge batteries
  - Makes energy-harvesting ever more practical

**No More Dead Batteries**

**One Less Thing to Worry About !**