

Power Efficiency and Mangement

KTH/CSD course kick-off
Fall 2013
Robert Olsson

Power Efficiency and Management

Why do we care?

”Short term”

- Environmental footprint
- New applications/possibilities/products
- New deployment & installations possible
- New research fields

A Question Of Balance

- Environmental footprint

Long time survival, we have no options.

Less power → Less heat

Less greenhouse gases including CO₂

Less use of natural resources, metals etc

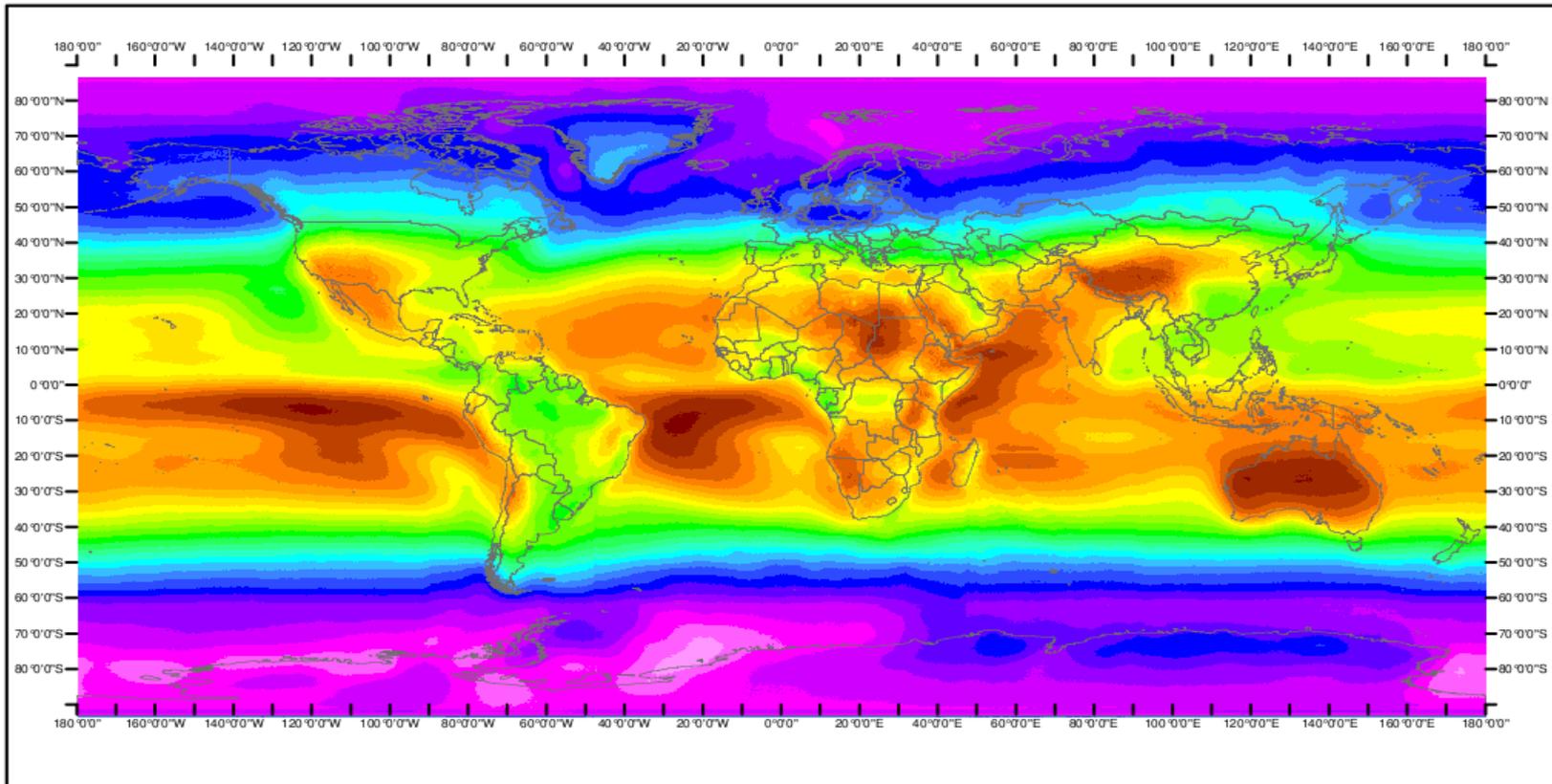
Solar Power

”The Sun provides Earth with as much energy every hour as human civilization uses every year ”

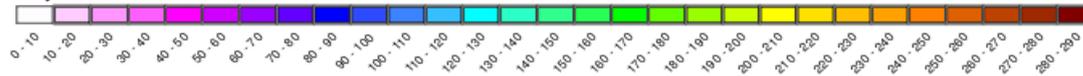
*Nature 443, 19-22 (7 September 2006) |
doi:10.1038/443019a; Published online 6
September 2006*

Solar Radiation

Averaged Solar Radiation 1990-2004

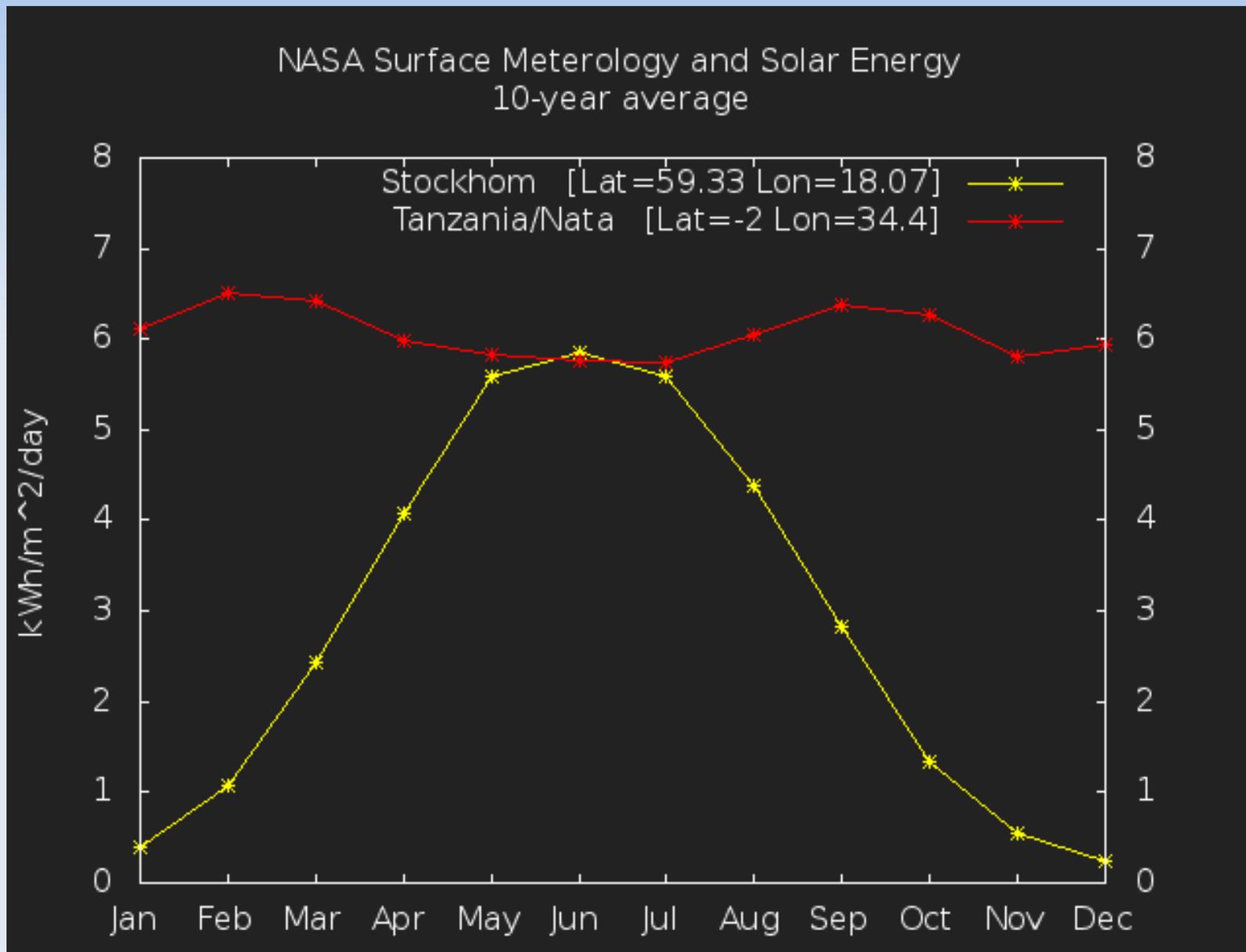


Yearly Mean of Irradiance in W/m^2



Realized by Michel Albuissou, Mireille Lefèvre, Lucien Wald.
Edited and produced by Thierry Ranchin. Date of production: 23 November 2006.
Centre for Energy and Processes, Ecole des Mines de Paris / Armines / CNRS.
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Insolation North-South



Power and Energy is not all

Solving the energy problem can help us solving our major

Problems:

- Water
- Food/Land
- Sustainability of resources
- Population growth

Arable land

Foodprint. → Size of land needed for 1 person
Global available 0.22 ha arable land per person

- World citizen uses 0.29 ha
- Sweden 0.46 uses ha
- World 2025 is 0.19 ha available (8 Billions)

World's birth, mortality, growth

World's annual birth, mortality and growth rate:

Birth: 1.915%,

Mortality 0.812%

Growth: 1.092%

Source: [CIA World Factbook \(ISSN 1553-8133\)](#)

World's population 2011:

7 Billion people

Source: United Nations Population Fund. Estimate
31.10.2011

Gives an increase of approx 210.000 people/day

Challenging economics

A discussed work:

Prosperity without growth (Economics for a Finite Planet)

Tim Jackson

Power Efficiency and Management Motivation

- New applications/possibilities/products
 - Networking devices, new environments
 - Powered by renewable energy
 - Longer running time for battery operated
Devices as laptop and mobiles etc.
 - Lot's of new possibilities
- New deployment & installations possible

Research & Development

- Areas of research
 - Operating systems
 - Network architecture/routing protocol
 - Hardware development/sleep modes etc
 - Sensors
 - Grid optimization and mini-grids
 - Social/professional networking
 - Etc

Power Efficiency and Management

Major tasks:

- Energy capture/harvest/collection
- Energy storage
- Energy transformation

Solar technology

Photovoltage Comercial Solar Technology

- Sun $\sim 1000 \text{ Watt/m}^2$
- Silicon-based monocrystalline. Efficiency. 12-20%
- Silicon-based polycrystalline. Efficiency. 12-20%
- Heat (indirect solar)
- Thin-film based. Many variants. Lower efficiency

Power In The Wind

$$P = \frac{1}{2} * \text{air density} * \text{swept area} * \text{windspeed}^3$$

- Air density 1.23 kg/m³ (at sea level)
- Swept area = $r^2 * \pi$

Further fluid dynamics limits power to 59.20%.
Betz limit. (Albert Betz 1919)

Power In The Wind/Example

$$P = \frac{1}{2} * \text{air density} * \text{swept area} * \text{windspeed}^3$$

- Rotor Diameter = 2 meter
- Wind Speed = 2 meter/sec

$$P = \frac{1}{2} * 1.23 * 1^2 * \pi * 2^3$$

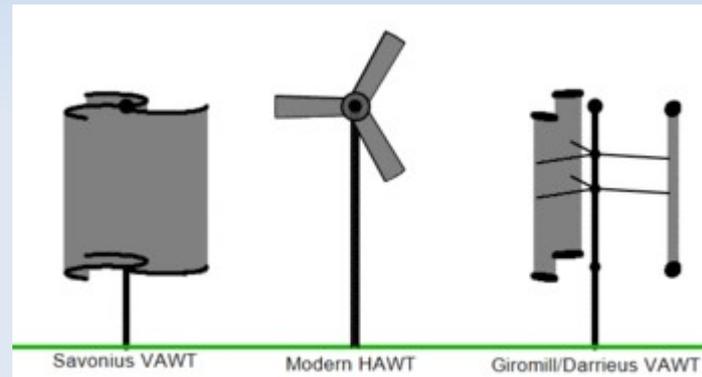
$$P = 1.23 * \pi * 4$$

$$\underline{P = 15 \text{ Watt}}$$

Next Betz limit 0.59

And we have even more losses...

Wind turbines

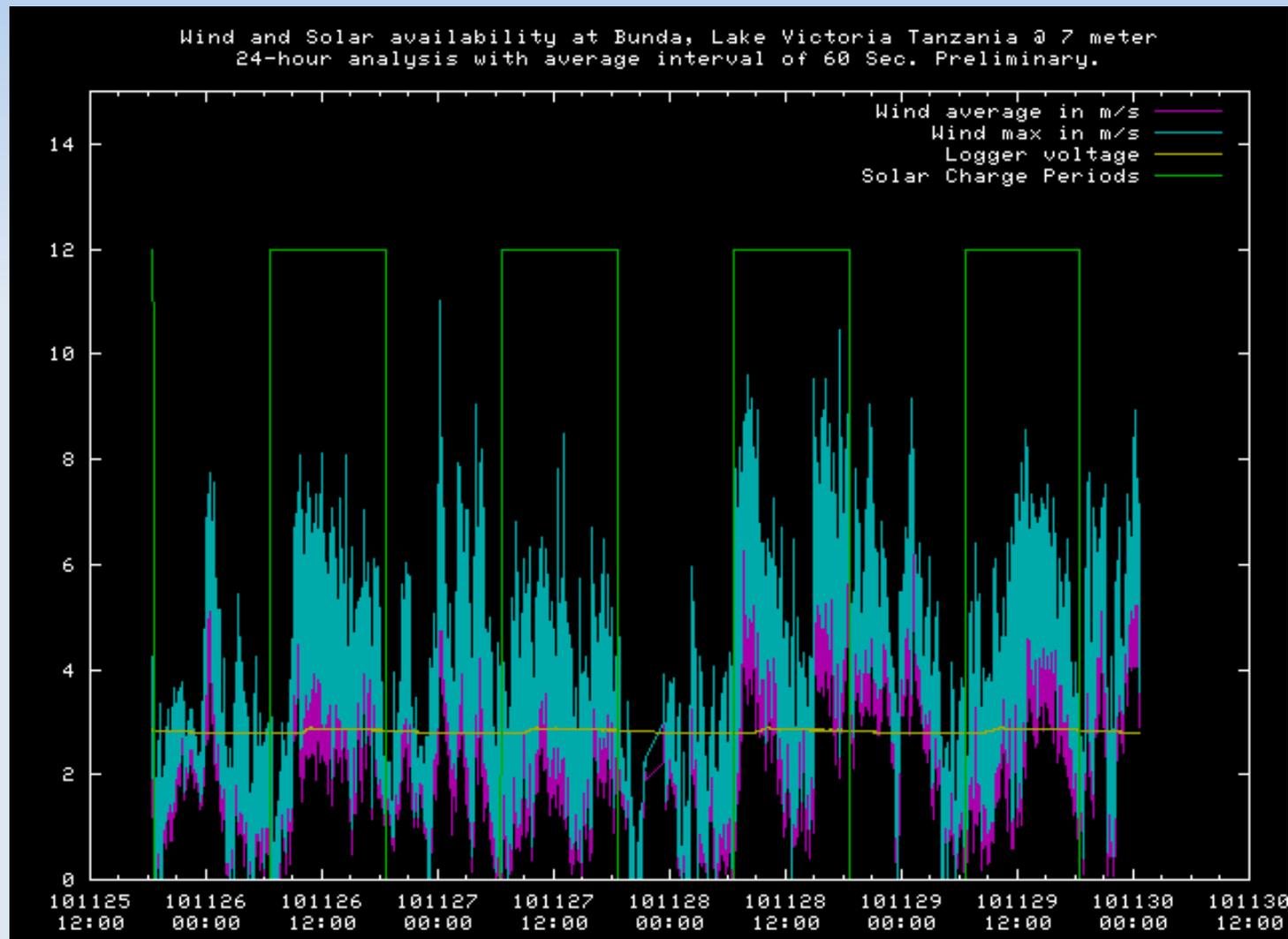


Wind Speed Monitoring/Bunda



Anemometer. A device that records wind speed.

Wind speed data/Bunda ~2 m/s



Energy Storage Challenges

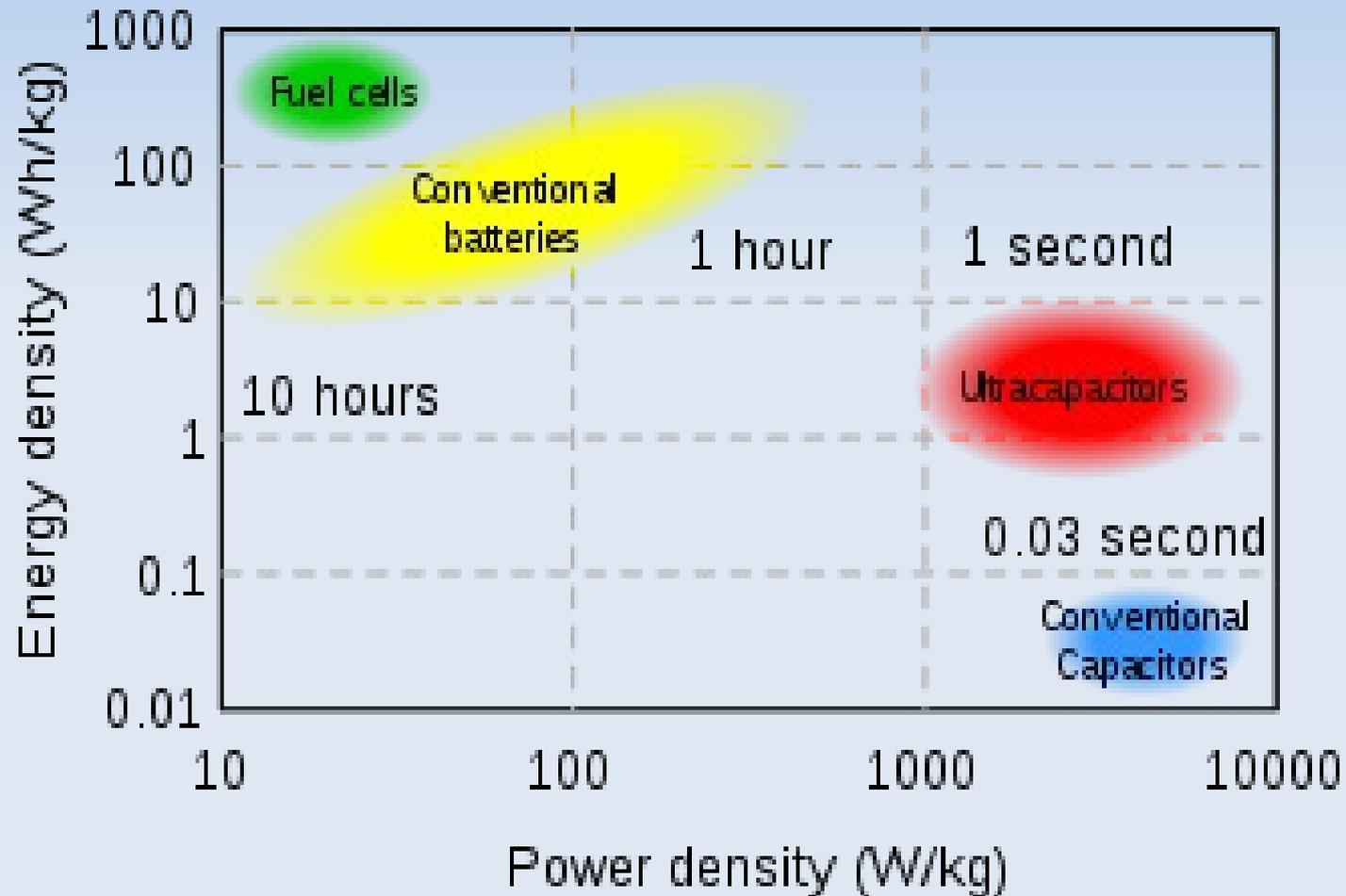
- High Storage Capacity
- Fast charging/Decharging
- Wide Temperature Range
- High Number Deep Cycles/Long Lifetime
- Low Price
- No rare metals, poisons etc
- Safe

Ultracapacitor Effort

Ultra-Capacitor bank with 16 caps @ 3000 Farad



Power vs Energy



Minne3 router chassis development

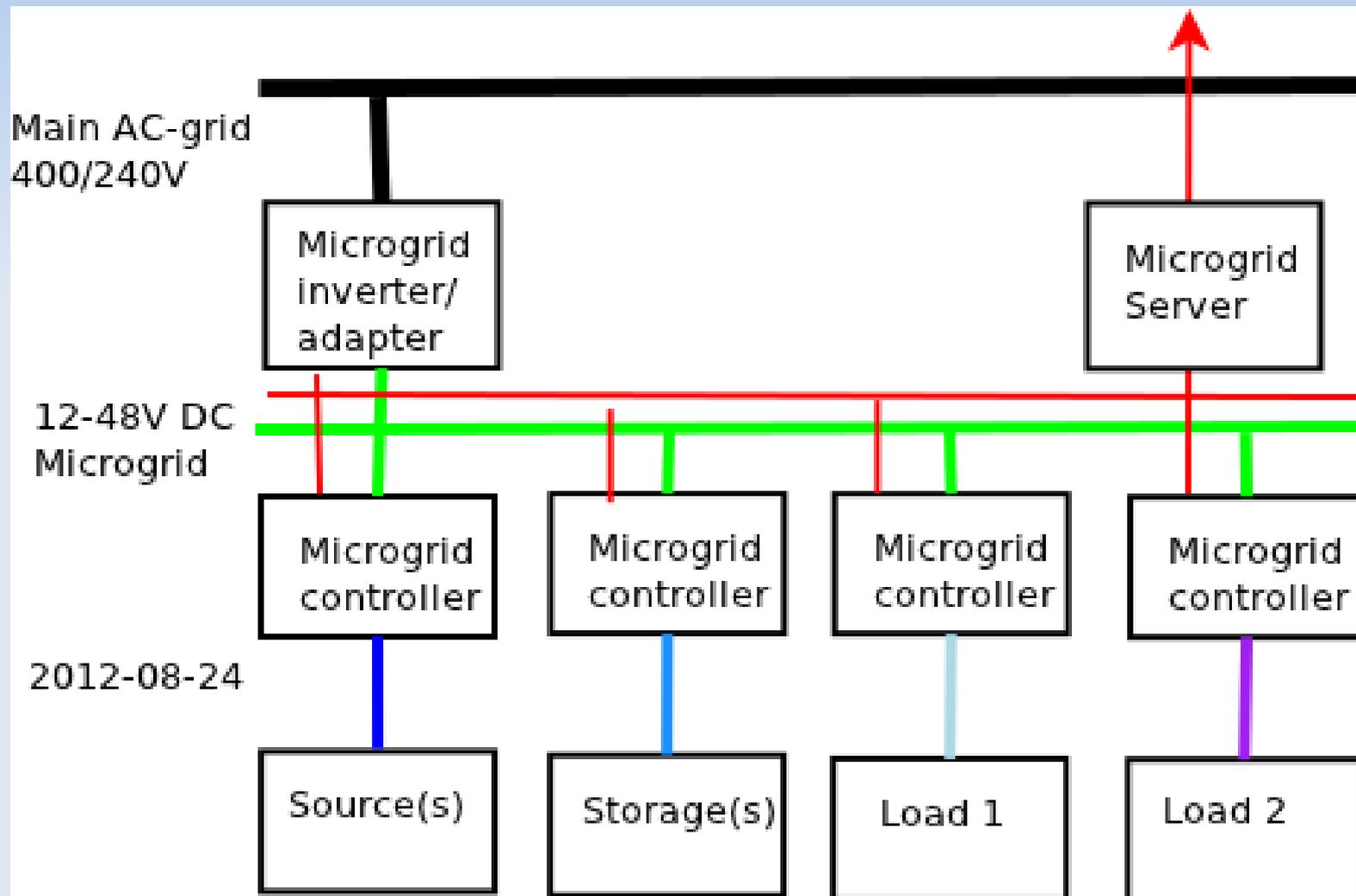
Low-power router w. passive cooling and power options



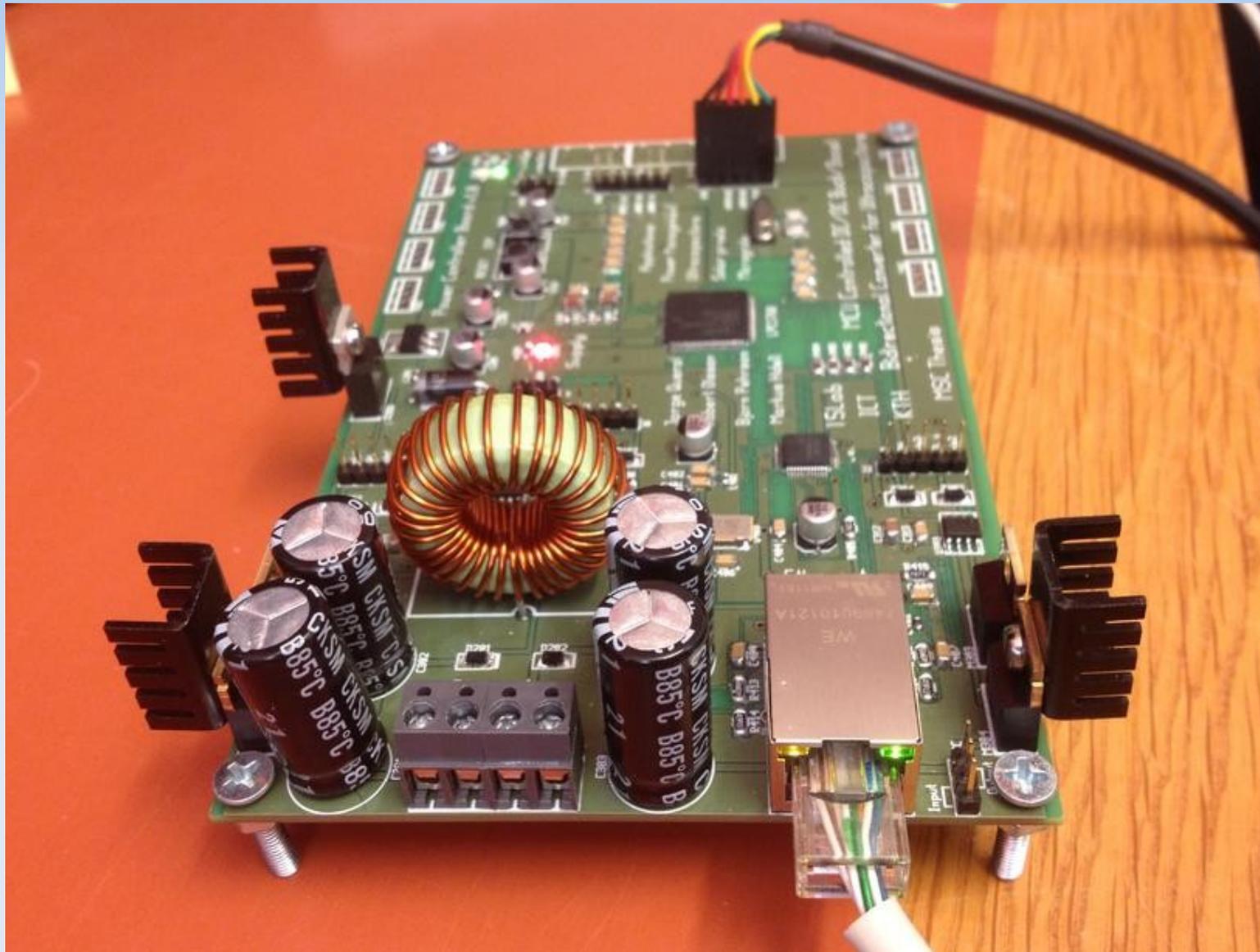
Power Efficiency. Radio vs Fibre

- Fiber 1 mW ----> 160 km @ Gigabit Ethernet
- Radio 100 mW ----> 1000 m (approx for hi-freq)

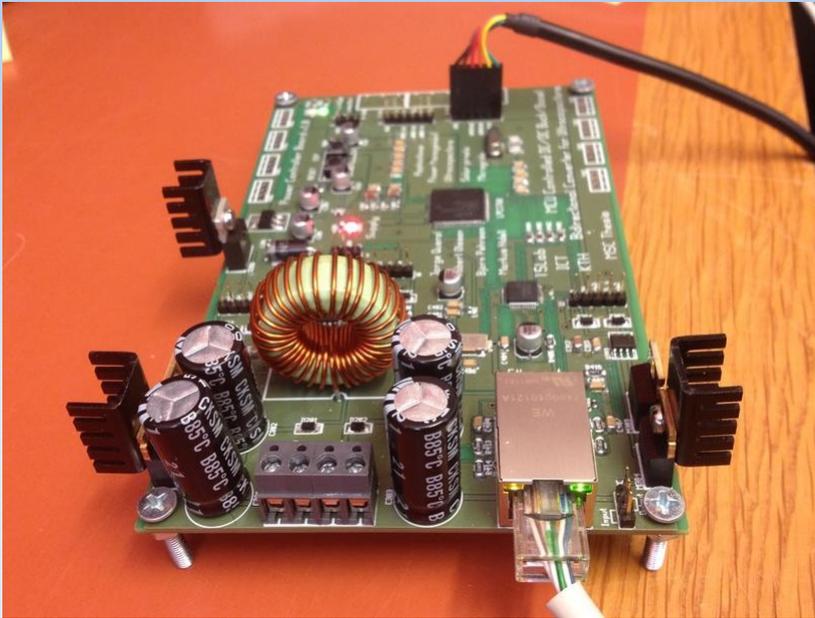
Small grid efforts



Small grid efforts DC-DC



Small grid efforts DC-DC



KTH Thesis project.

KTH CSD/SoC project ported Contiki to board

CoAP IETF protocol, IoT-grid code.

Code available from github

Power Efficiency and Mangement

Questions ?