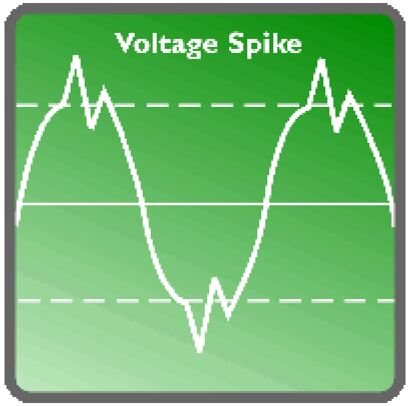
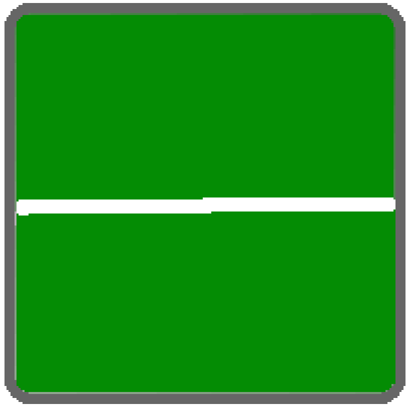
NRENs,

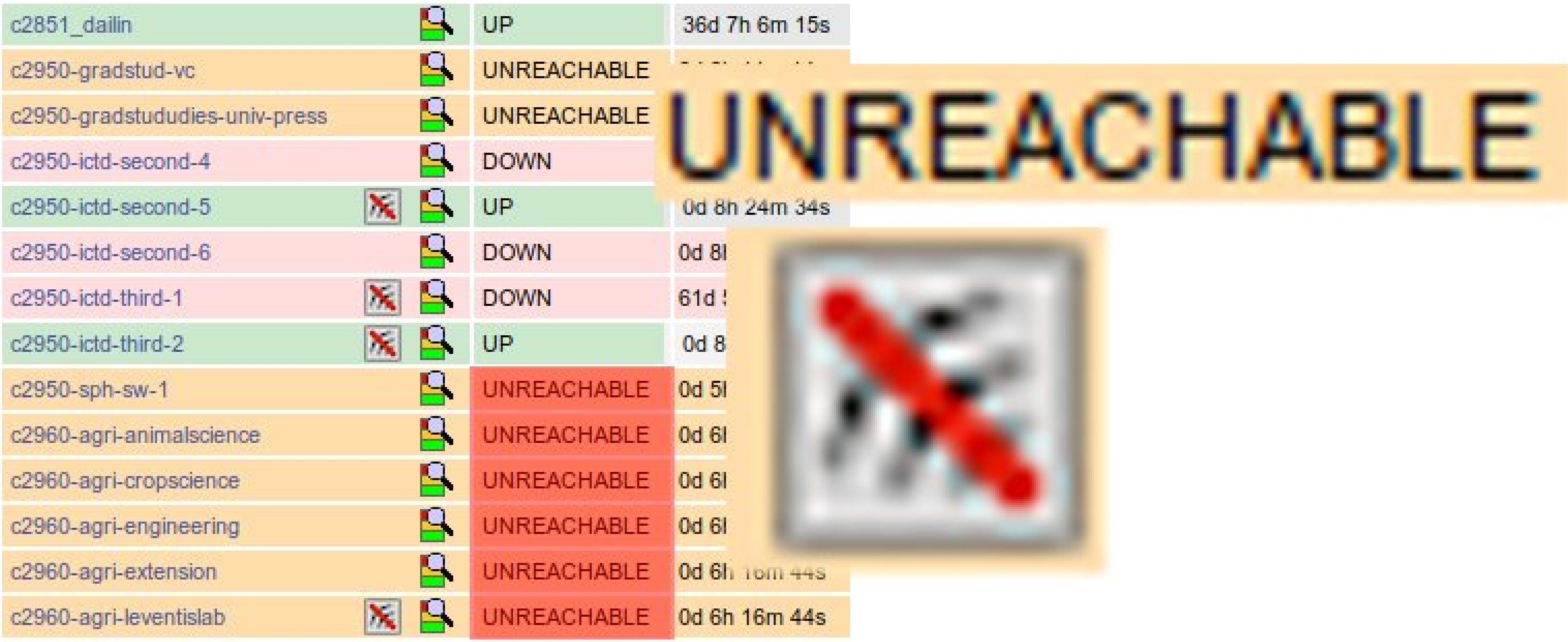
Connectivity & Power

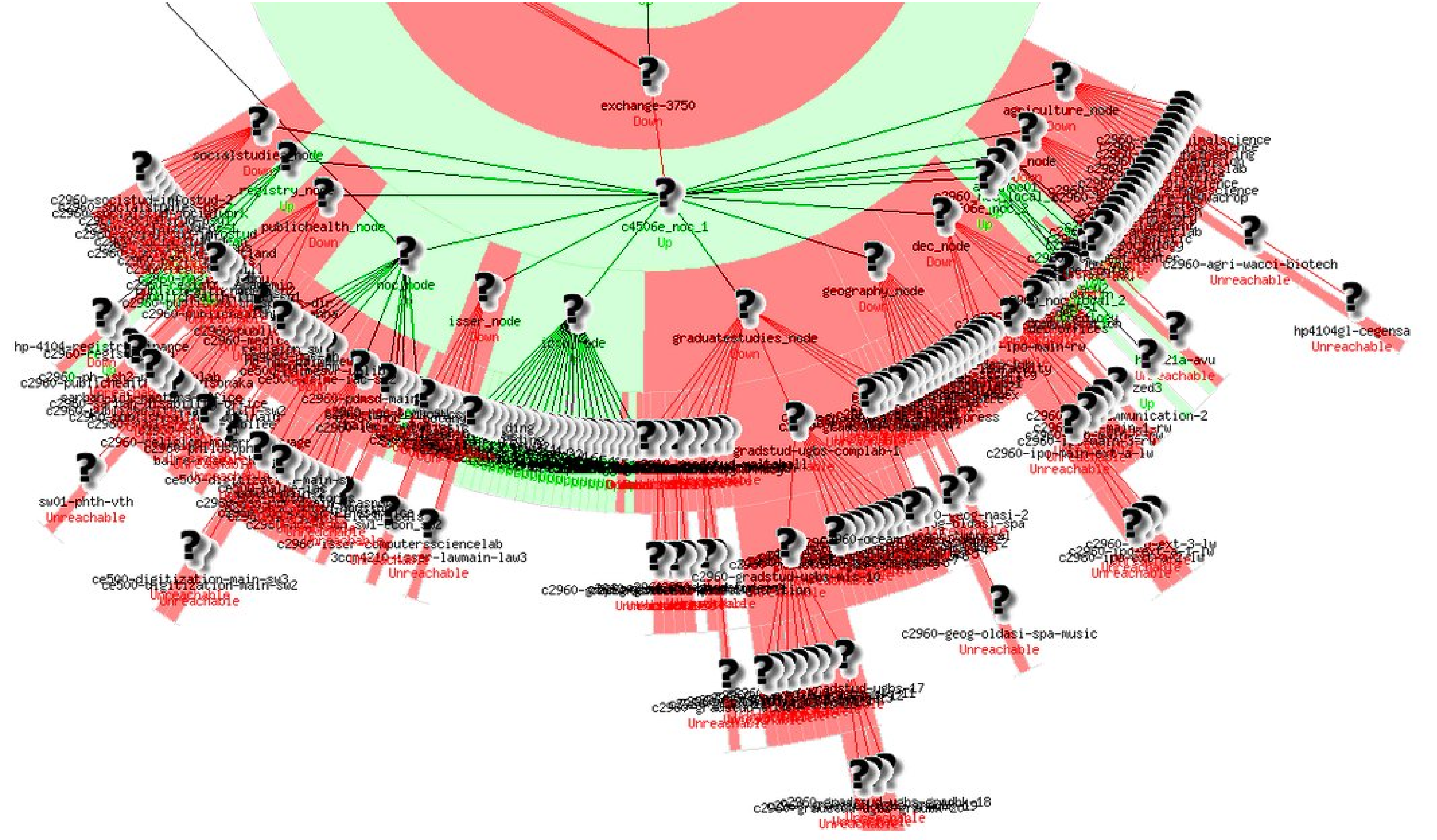
Grid power reality





Power is frequently named as
biggest obstacle in building networks -
before skills/capacity and budget.


c2851_dailin UP 36d 7h 6m 15s
c2950-gradstud-vc UNREACHABLE
c2950-gradstududies-univ-press UNREACHABLE
c2950-ictd-second-4 DOWN
c2950-ictd-second-5 UP
c2950-ictd-second-6 DOWN
c2950-ictd-third-1 DOWN
c2950-ictd-third-2 UP
c2950-sph-sw-1 UNREACHABLE
c2960-agri-animalscience UNREACHABLE
c2960-agri-cropscience UNREACHABLE
c2960-agri-engineering UNREACHABLE
c2960-agri-extension UNREACHABLE
c2960-agri-leventislab UNREACHABLE 0d 6h 16m 44s
UNREACHABLE


exchange-3750
Down
c4506e_noc_1
Up
agriculture_node
publichealth_node
noc_node
isser_node
graduatestudies_node
geography_node
dec_node
c2960-agri-wacci-biotech
hp4104gl-cegensa
sw01-phth-vth
ce500-digitization-main-sw3
c2960-isser-computersciencelab
3ccm4210-isser-lawmain-law3
c2960-geog-oldasi-spa-music
c2960-ipo-main-ext-a-lw
Unreachable

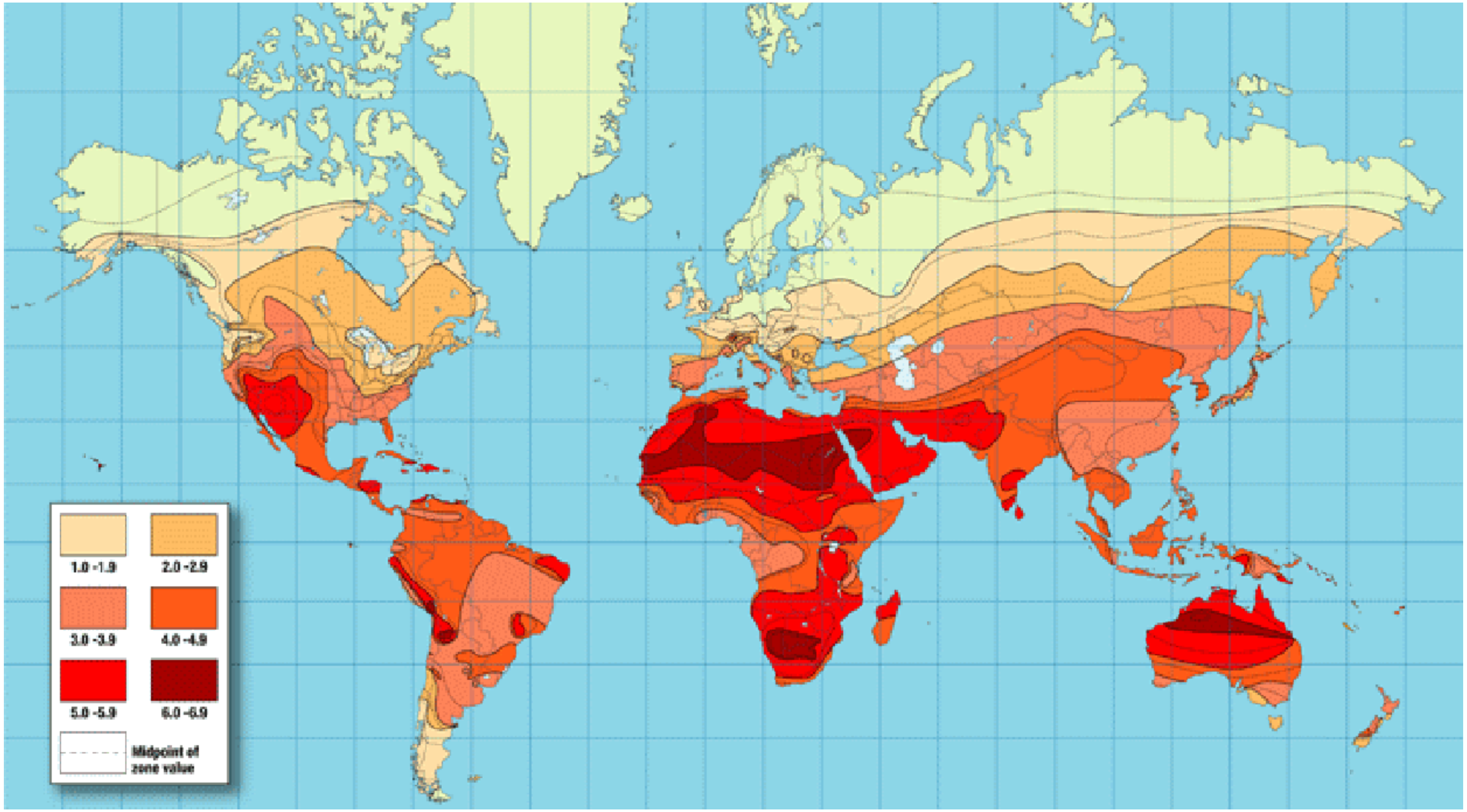
Unstable power not only leads to
service disruptions,
it also
kills hardware,
leading to
massive losses of investments.

Building networks without solving the power issue
is like
trying to fill a bottomless bucket.

Networkers and Funders alike
have all pragmatic
reasons to act.

Luckily, we know **how to**
and we often work in ...

Truly rich countries



The roof of a
University IT building in Nairobi, Kenya
receives about
2200 kWh/sqm/year
or an average
250 W/sqm.

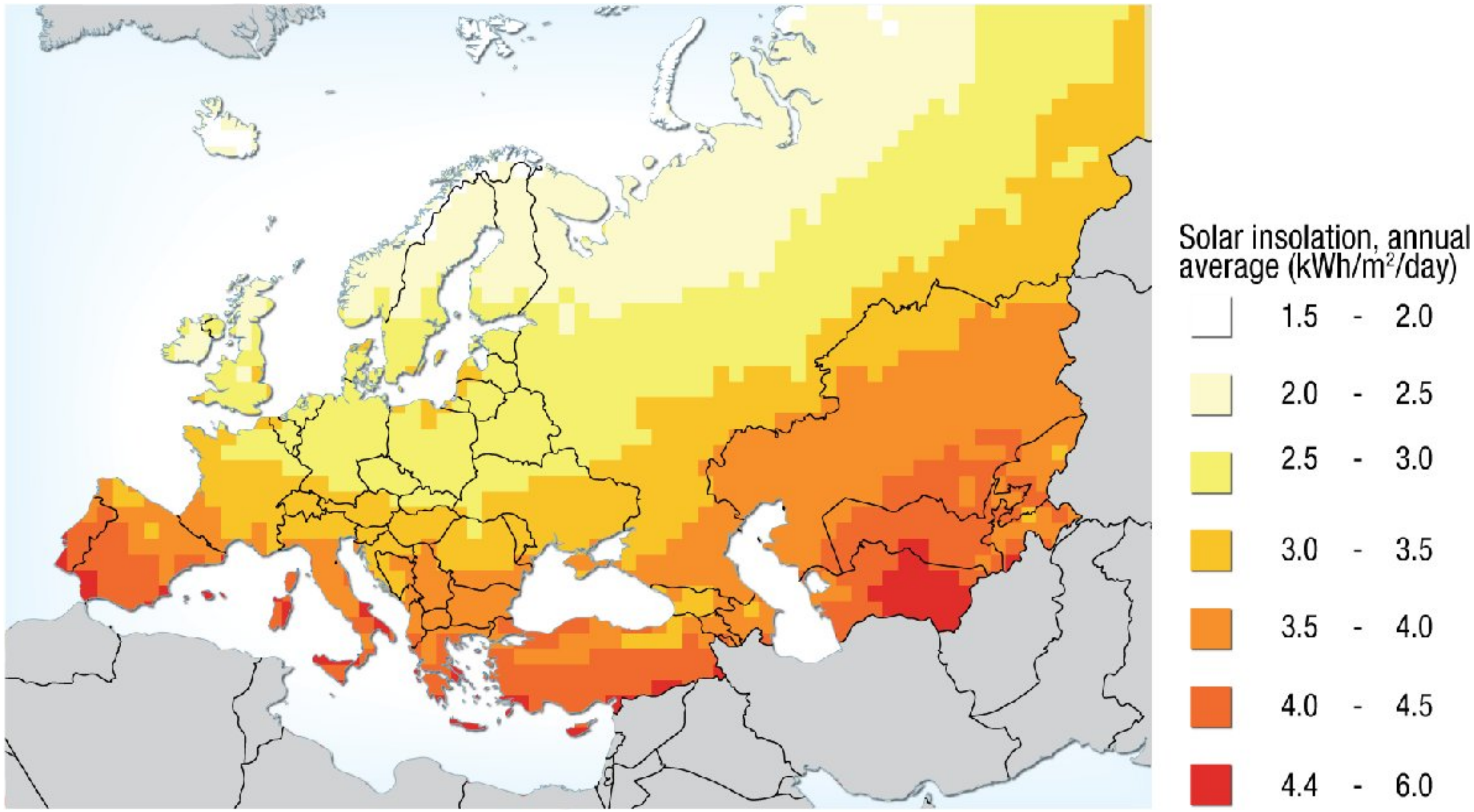
It gets an average
6 peak sun hours every day.

[redacted]

[redacted]

Dark Germany gets about

2 peak hours per day, yet ...



Germany sets world record for solar power generation

By Madonna Gauding Published: June 15, 2012

Posted in: Energy, Environment, Technology

Tags: Fossil fuel subsidies , Germany , Solar energy

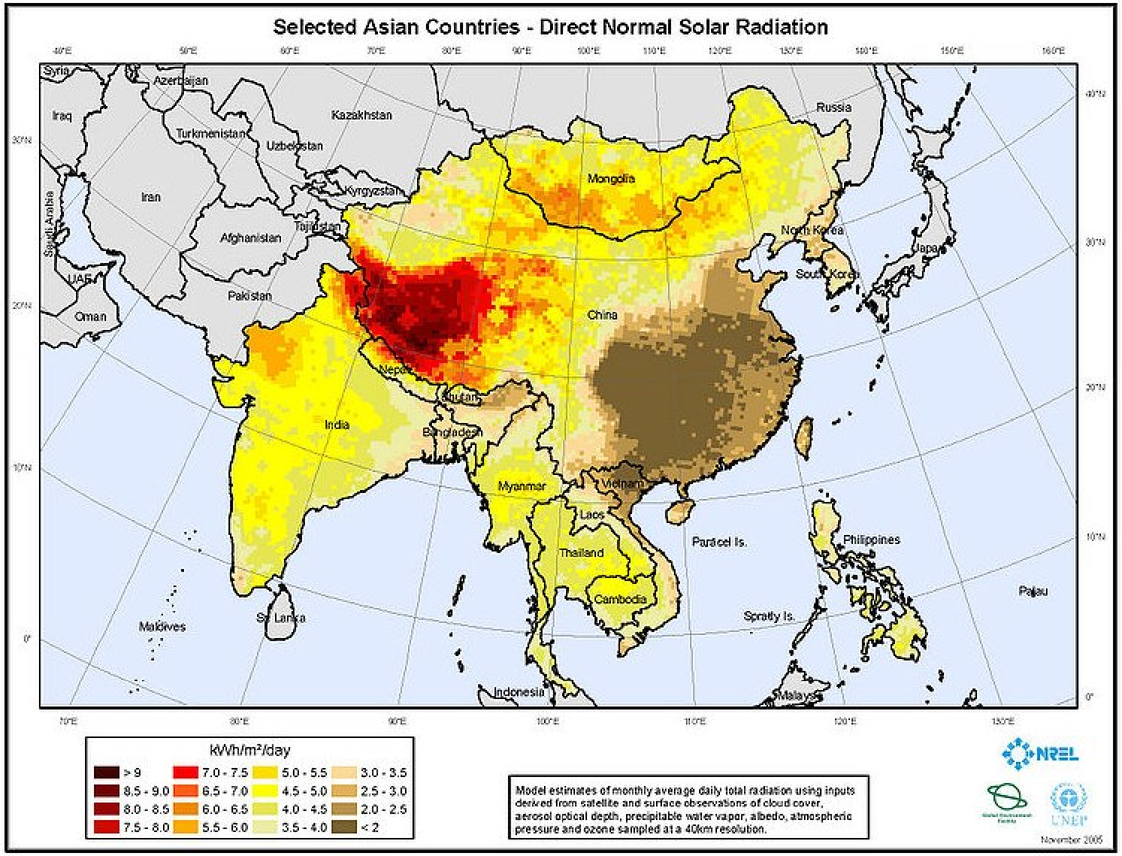
50% of its total electricity from solar sources (on a very good summer day :)

Data for Asia

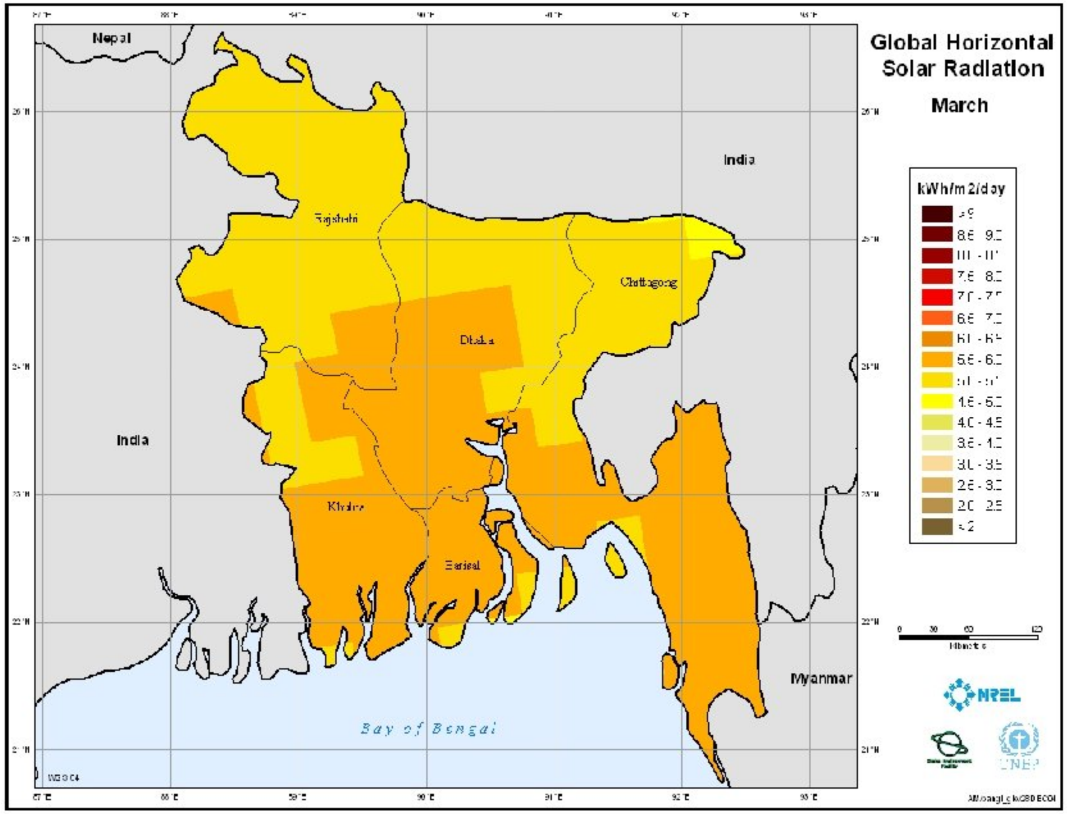
http://reegle.info

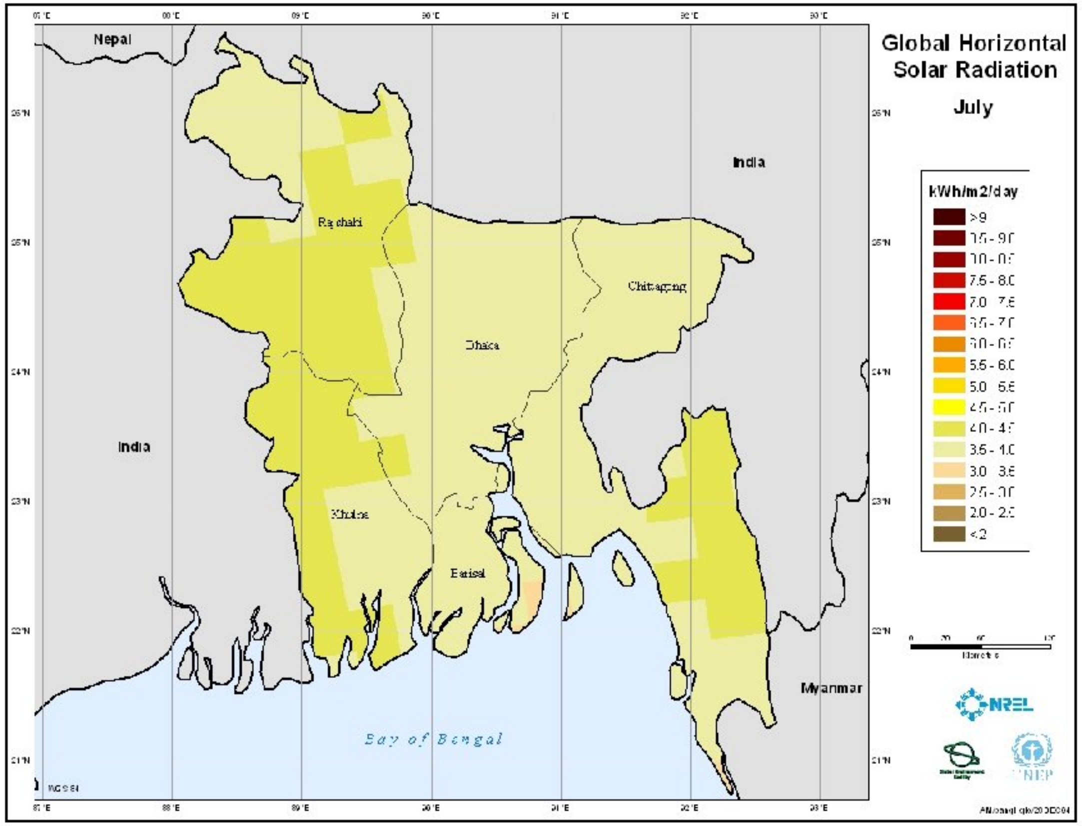
http://en.openei.org/

http://nrel.gov

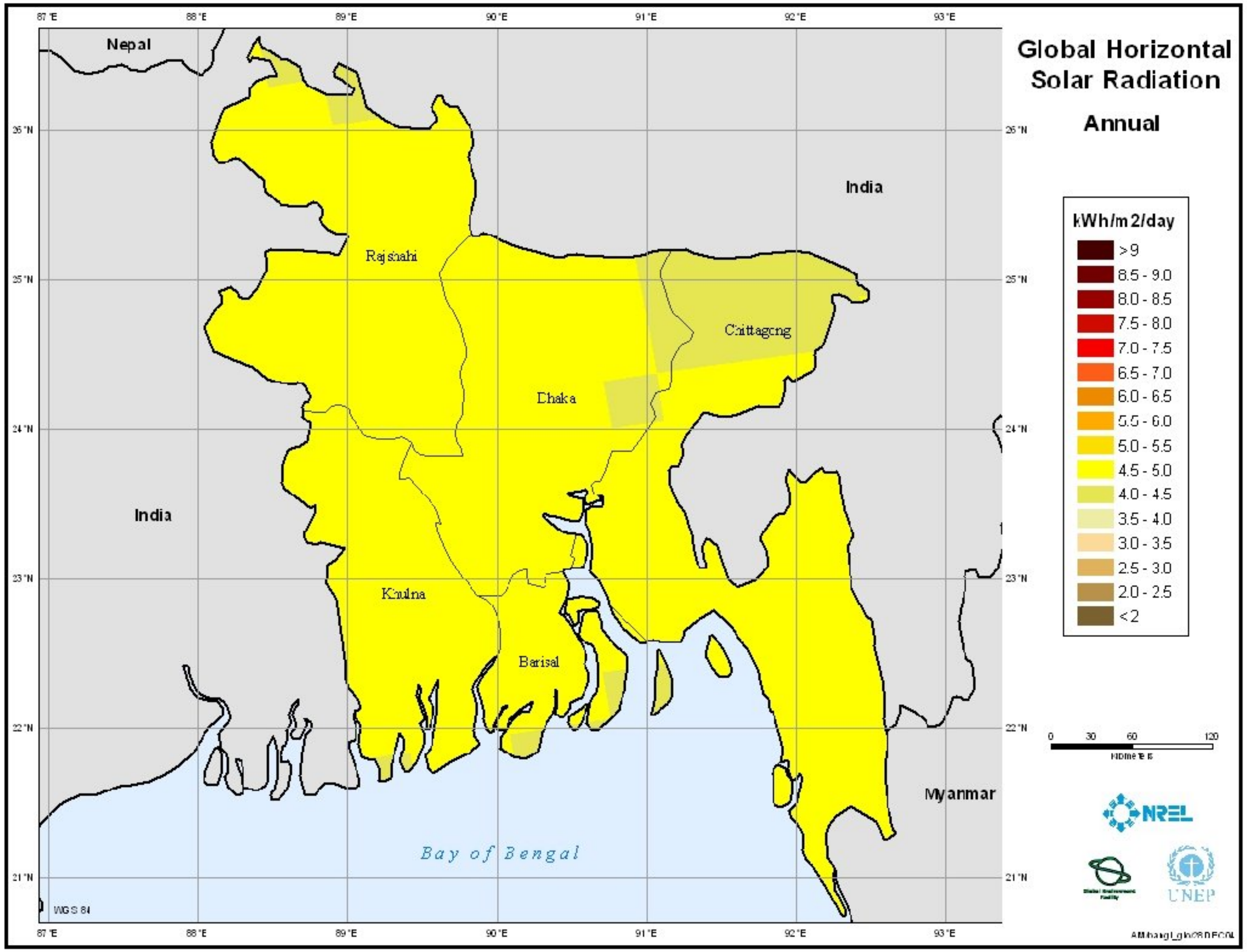


Data for Bangladesh

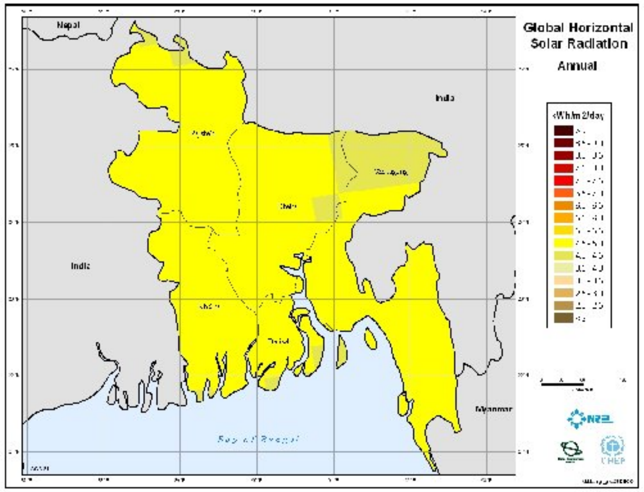


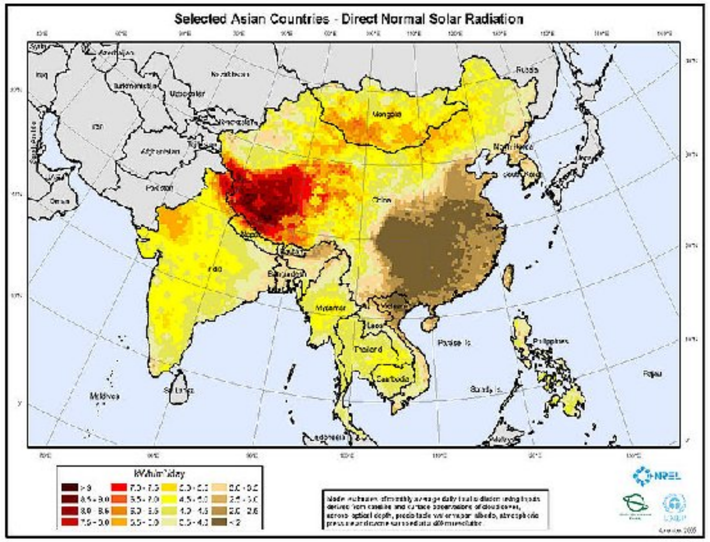

Global Horizontal
Solar Radiation
July
kWh/m2/day
>9
7.5 - 8.0
<2
Nepal
India
India
Myanmar
Rajshahi
Dhaka
Chittagong
Khulna
Barisal
Bay of Bengal
NREL
UNEP

[redacted]



[redacted]





Bangladesh gets an average

4-5 peak sun hours every day.

What part of that energy can we harvest?

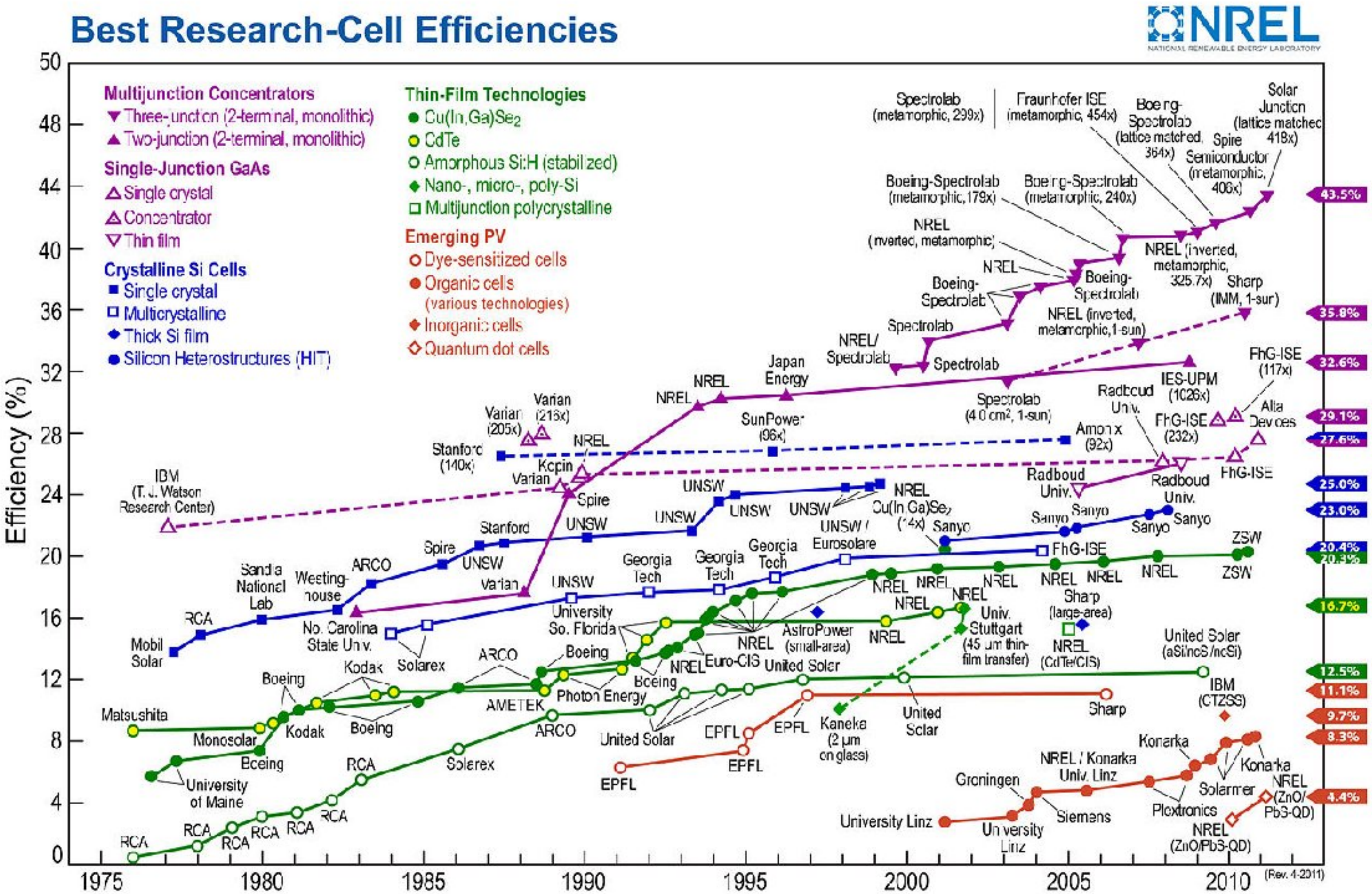
Cells currently available

typically have < 20 % **conversion efficiency**

Realistic values of monochrystalline cells: approx. **15%**.

Intense research to improve efficiency

Manufacturer Name	Module Model Number	PTC	Area (sqft)	PTC/ Sqft	Description
SunPower Corporation	SPR-230-WHT-U	209.5	13.395	**15.64**	230W Monocrystalline Module, White Backsheet
SunPower Corporation	SPR-225-BLK-U	201.9	13.395	**15.073**	225W Monocrystalline Module, Black Backsheet
Sanyo Electric Co. Ltd.	HIP-215NKHA1	199.6	13.486	**14.801**	215W HIT Power N Hybrid Amorphous/Monocrystalline
SunPower Corporation	SPR-220-WHT-U	198.2	13.395	**14.797**	220W Monocrystalline Module, White Backsheet
SunPower Corporation	SPR-220-BLK-U	197.3	13.395	**14.729**	220W Monocrystalline Module, Black Backsheet
Sanyo Electric Co. Ltd.	HIP-210NKHA1	194.9	13.486	**14.452**	210W HIT Power N Hybrid Amorphous/Monocrystalline
SunPower Corporation	SPR-215-WHT-U	193.5	13.395	**14.446**	215W Monocrystalline Module, White Backsheet
Sanyo Electric Co. Ltd.	HIP-205BA19	190.7	13.486	**14.141**	HIT Power 205W - Hybrid Amorphous/Monocrystaline
SunPower Corporation	SPR-210-WHT-U	189	13.395	**14.11**	210W Monocrystalline Module, White Backsheet
Sanyo Electric Co. Ltd.	HIP-205NKHA1	190.2	13.486	**14.104**	205W HIT Power N Hybrid Amorphous/Monocrystalline
SunPower Corporation	SPR-210-BLK-U	188.1	13.395	**14.043**	210W Monocrystalline Module, Black Backsheet
SunPower Corporation	SPR-205-BLK-U	183.6	13.395	**13.707**	205W Monocrystalline Module, Black Backsheet
Schuco USA LP	SPV 210 SMAU-1	192.1	15.766	**12.184**	210W Monocrystalline Module, Black Frame
Siliken California Corp	SLK60P6L 235 Wp	210.7	17.476	**12.056**	235W Polycrystalline Module
Siliken California Corp	SLK60P6L 230 Wp	206.1	17.476	**11.793**	230W Polycrystalline Module
REC ScanModule AB	REC230AE-US (BLK)	200.7	17.025	**11.789**	230W Polycrystalline Module, High Performance
Solon Ag Fuer Solartechnik	P220/6+/01 235Wp	208	17.653	**11.783**	235W Polycrystalline Module
Suntech Power Co.	STP280-24/Vb-1	246	20.908	**11.766**	280W Polycrystalline Module, MC Connectors
ET Solar Industry, Ltd	ET-P672270	241.8	20.908	**11.565**	270W Polycrystalline Module
aleo solar AG	S18.230	204.5	17.689	**11.561**	230W Polycrystalline Module
REC ScanModule AB	SCM225	196.5	17.025	**11.542**	225W Polycrystalline Module
Siliken California Corp	SLK60P6L 225 Wp	201.5	17.476	**11.53**	225W Polycrystalline Module
Solon Ag Fuer Solartechnik	P220/6+/01 230Wp	203.4	17.653	**11.522**	230W Polycrystalline Module
ET Solar Industry, Ltd	ET-P672265	237.1	20.908	**11.34**	265W Polycrystalline Module
Suntech Power Co.	STP270-24/Vb-1	236.9	20.908	**11.331**	270W Polycrystalline Module, MC Connectors
aleo solar AG	S18.225	199.9	17.689	**11.301**	225W Polycrystalline Module
Sharp Corporation	ND-U230C1	198	17.541	**11.288**	230W Polycrystalline Module, Locking Connector
Solartech Power Inc.	SPM230P	197.9	17.541	**11.282**	230W Polycrystalline Module
REC ScanModule AB	SCM220	192	17.025	**11.278**	220W Polycrystalline Module
Siliken California Corp	SLK60P6L 220 Wp	197	17.476	**11.272**	220W Polycrystalline Module


Best Research-Cell Efficiencies
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Efficiency (%)
Multijunction Concentrators
Three-junction (2-terminal, monolithic)
Two-junction (2-terminal, monolithic)
Single-Junction GaAs
Single crystal
Concentrator
Thin film
Crystalline Si Cells
Single crystal
Multicrystalline
Thick Si film
Silicon Heterostructures (HIT)
Thin-Film Technologies
Cu(In,Ga)Se2
CdTe
Amorphous Si:H (stabilized)
Nano-, micro-, poly-Si
Multijunction polycrystalline
Emerging PV
Dye-sensitized cells
Organic cells
(various technologies)
Inorganic cells
Quantum dot cells
43.5%
35.8%
32.6%
29.1%
27.6%
25.0%
23.0%
20.4%
20.3%
16.7%
12.5%
11.1%
9.7%
8.3%
4.4%
1975
1980
1985
1990
1995
2000
2005
2010
(Rev. 4-2011)

Anywhere, it is enough to power network components, computer labs and even server rooms ...

It is fully realistic and

about time to set a goal:

Only deploy networks and IT infrastructure

that you can power autonomously.

Today that s the only choice, in many places.

For tomorrow, it is the right way to go anyway.

That s not a popular view (yet), as long as the diesel backup is there,

and the cost of solar seems(!) high.

The task begins with ...

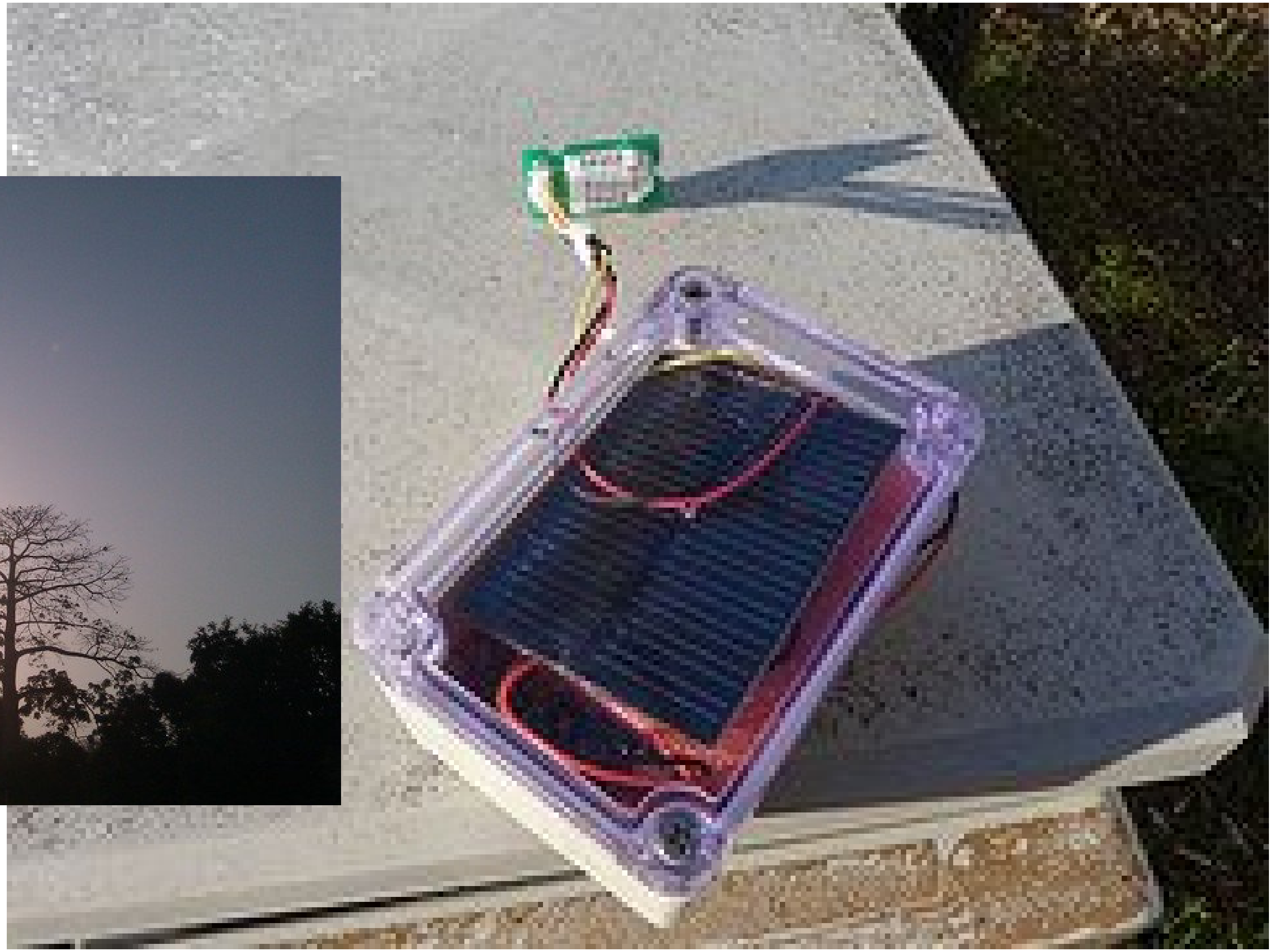
Understanding and minimizing load

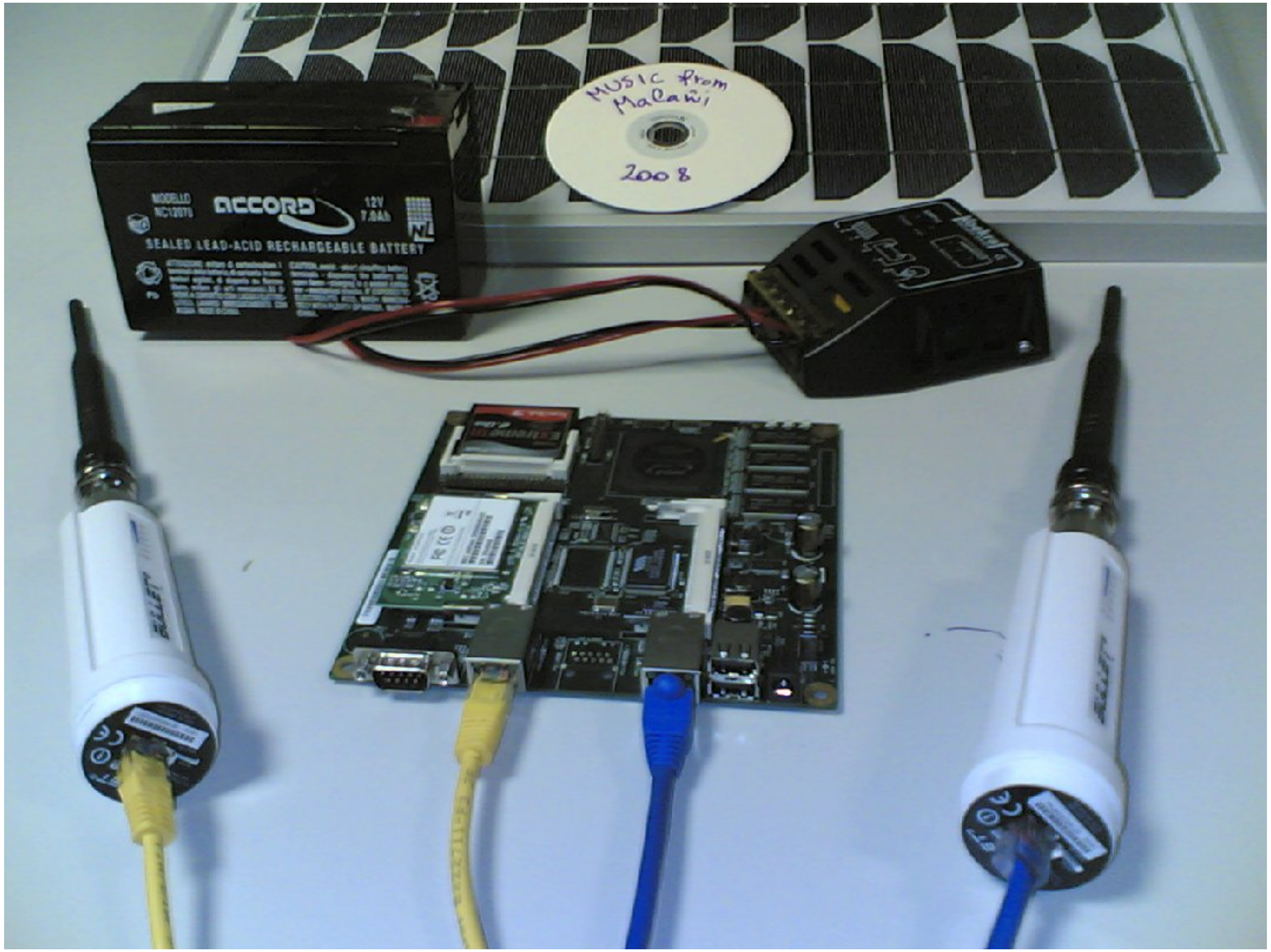
- virtual servers, smart low power servers
- Complete workstations for < 20 W, modern laptops instead of old refurbished Pcs
- Energy efficient wireless gear
- Run on DC where possible
- Use LED lights

Typically, looking at server rooms, classrooms and PC labs, you can bring them down to 10% of what they are using

[redacted]

[redacted]




MUSIC from Malawi
2008
ACCORD
12V
7.0Ah
SEALED LEAD-ACID RECHARGEABLE BATTERY

But, what s the cost?

Prices

Prices have reached

< \$1 / W_p for quality panels

(in range ~100...1000 Watt) -

For whole systems (incl batteries, controllers, etc) in the kW range, \$3 - 5 / W_p is a reasonable assumption.

Dimensioning a pv system

First rule: **minimize load!**

Collect realistic data for
insolation, load, time characteristics, etc

Conservative approach to dimensioning

- Know your load
- Decide how much uptime without recharge you need (longest dark period)
- ==> Battery Capacity
- Decide how long it may take to recharge the battery
- ==> Solar panel size

Appendix: Dimensioning exercise

Dimensioning a photovoltaic system: First approximation

You could call this the "battery approach" - we start with

- looking at the total load of consuming devices
- how long we need to keep them running without sun -
- then we calculate the battery capacity and everything else from there.

All numbers here are of course just examples – total load, insolation hours and other factors will be different from case to case!

To start, we need to know two things:

Total Load at 12 Volts [W]: e.g. 20 Watt (==> 1.7 A)

Days of Autonomy, that means: how long we can run without sun:

we will say 3 days a 8 hours a day ==> 24 hours.

These two lead us to ...

*Total Battery Capacity needed [Ah]: 40 = 24 h * 1.7 A*

However, no battery should be discharged completely ever - the maximum discharge depends on the type of battery. Read your data sheet!

What is the maximum discharge level of the batteries? e.g. 50%: 50%

With this correction, we get ...

Total Battery Capacity needed [Ah]: 80

Now that we know the battery capacity, we need to know how many days we allow for full recharging, once the sun is shining

Maximum time for recharging [days]: 1

How many hours of sun on an average day? 5

This gives us the total power of the solar panels needed – we will need to have 40/5 A flowing into the battery

We need this many Watts from the 12 Volts panels: 60 Watt!

60 Watt of panels to power 20 Watt of consumer devices, for some of the time.

And we are only using it 8 hours a day, and have not been demanding a long autonomy phase.
For nonstop operations, it would be approximately 200 Watts!

Let us look at the same system from a different angle.

Dimensioning a photovoltaic system: Second approximation

This is the "worst month approach", simplified. That means, we will

- calculate how much energy (power x time) we need per month
- take the month with the least sun
- see how many solar panels we need to generate the needed energy in that worst month

Again , we need to know the ...

Total Load at 12 Volts [W]: 20

How many hours per day do we need our devices running? 8

this tells us, how many AmpHours will be needed:

*Total AmpHours per month: 400 (30 days * 8 hours * 1.7 A)*

What are the average sunshine hours in the worst (darkest) month of the year?

150 (i.e. 5 hours a day ... a sunny climate)

These hours will have to be enough to generate the same amount of AmpHours we found above – this tells us how many watts of solar power we need:

Total Watts of 12 V Solar Panels: 32 Watt

Now we still need to know our battery capacity – again based on:

Days of Autonomy, that means: how long we can run without sun: 3

and

The maximum discharge level of the batteries? 50

This results in

Total Battery Capacity 50 Ah

This second approach leads to a far more optimistic result - only 1/2 of the solar panel power needed.

Discuss!

Why is this the case?

What does the "worst month model" neglect?

NRENs, universities and scientific networkers

can and should take a

leading role

on the way towards a fully

sustainable energy future.