The Smart Electricity Grid

Engineers Australia – Sydney Division

Southern Highlands and Tablelands Regional Group

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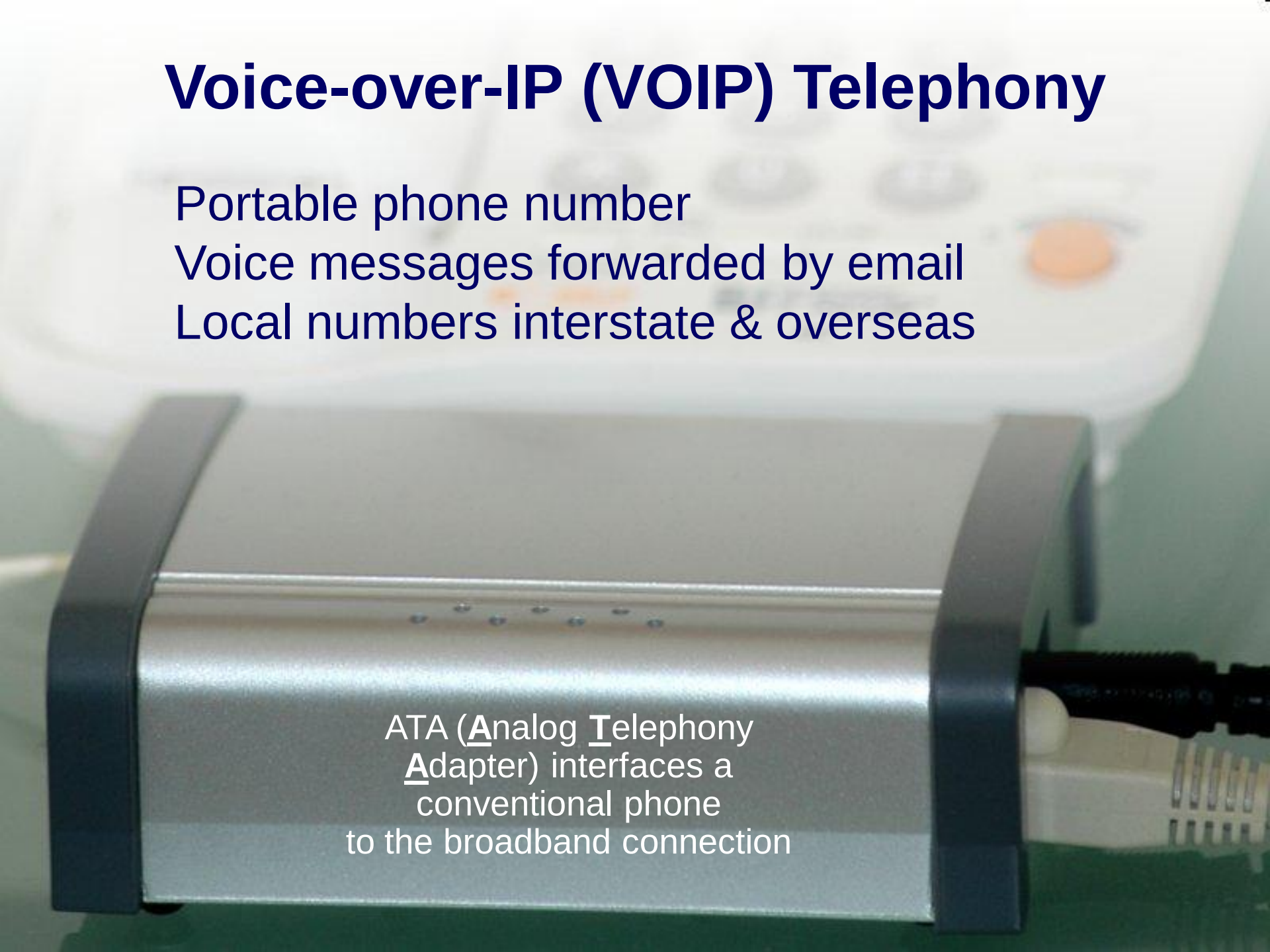
Think …
… about how broadband has changed the world over the last 15 years
Photo by Jacob Boetter

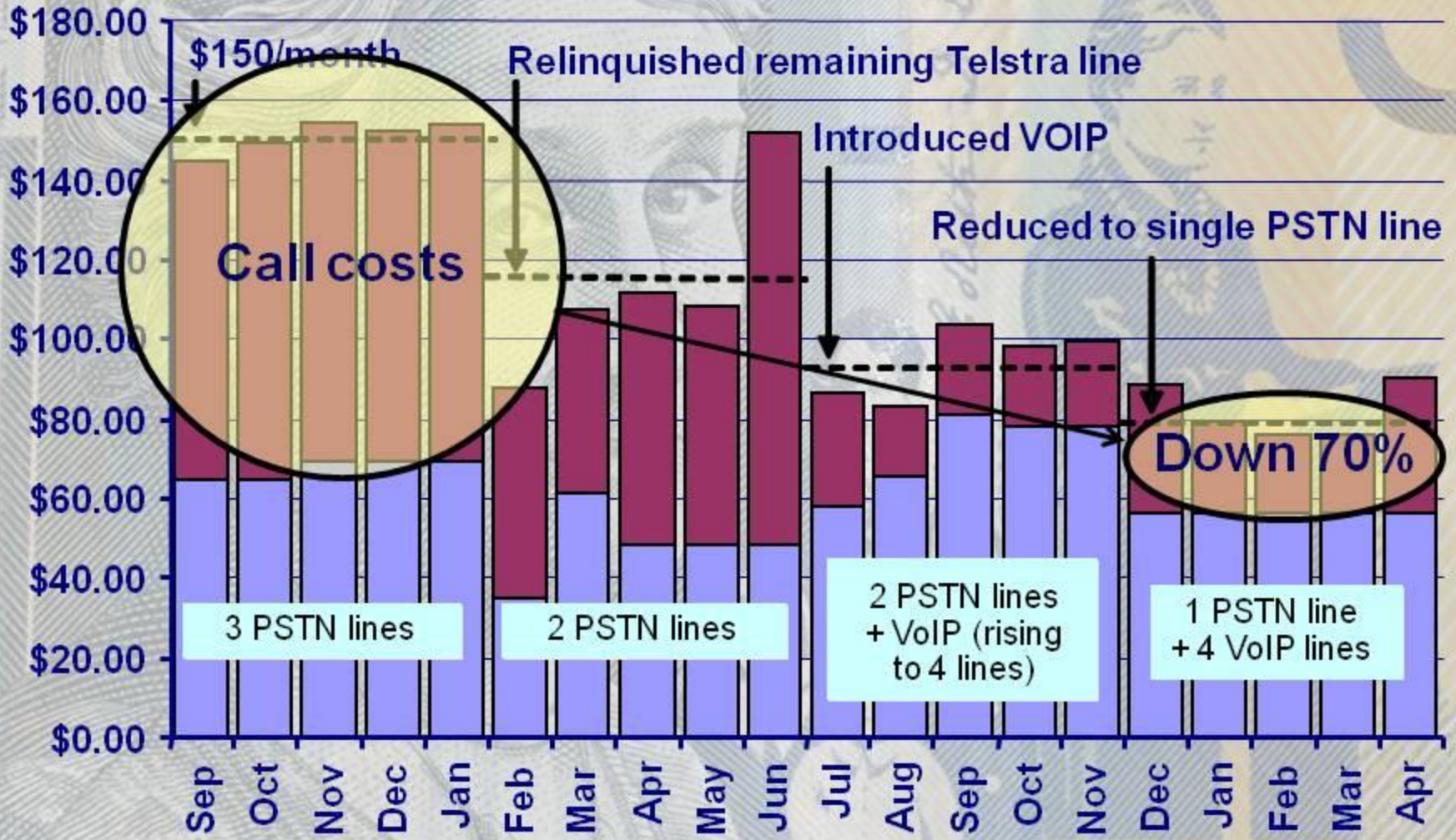
Voice-over-IP (VOIP) Telephony

Portable phone number
Voice messages forwarded by email
Local numbers interstate & overseas



ATA (**A**nalog **T**elephony **A**dapter) interfaces a conventional phone to the broadband connection

Big $avings


$180.00
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
$150/month
Relinquished remaining Telstra line
Introduced VOIP
Reduced to single PSTN line
Call costs
Down 70%
3 PSTN lines
2 PSTN lines
2 PSTN lines + VoIP (rising to 4 lines)
1 PSTN line + 4 VoIP lines
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr


BEETHOVEN
IL DIVO
ENCORE
PAUL SIMON
GRACELAND
MP3 Music


New &
better
approaches
to old
problems

Check the premises from anywhere in the world via the Internet

Multi-camera view

Mobile Phone Access

Send

1 2 3 4

Recording

1 2 3 4

SMS Alerts

R L M J

Control

Feed Seve

Delivery

Garage

Buzz

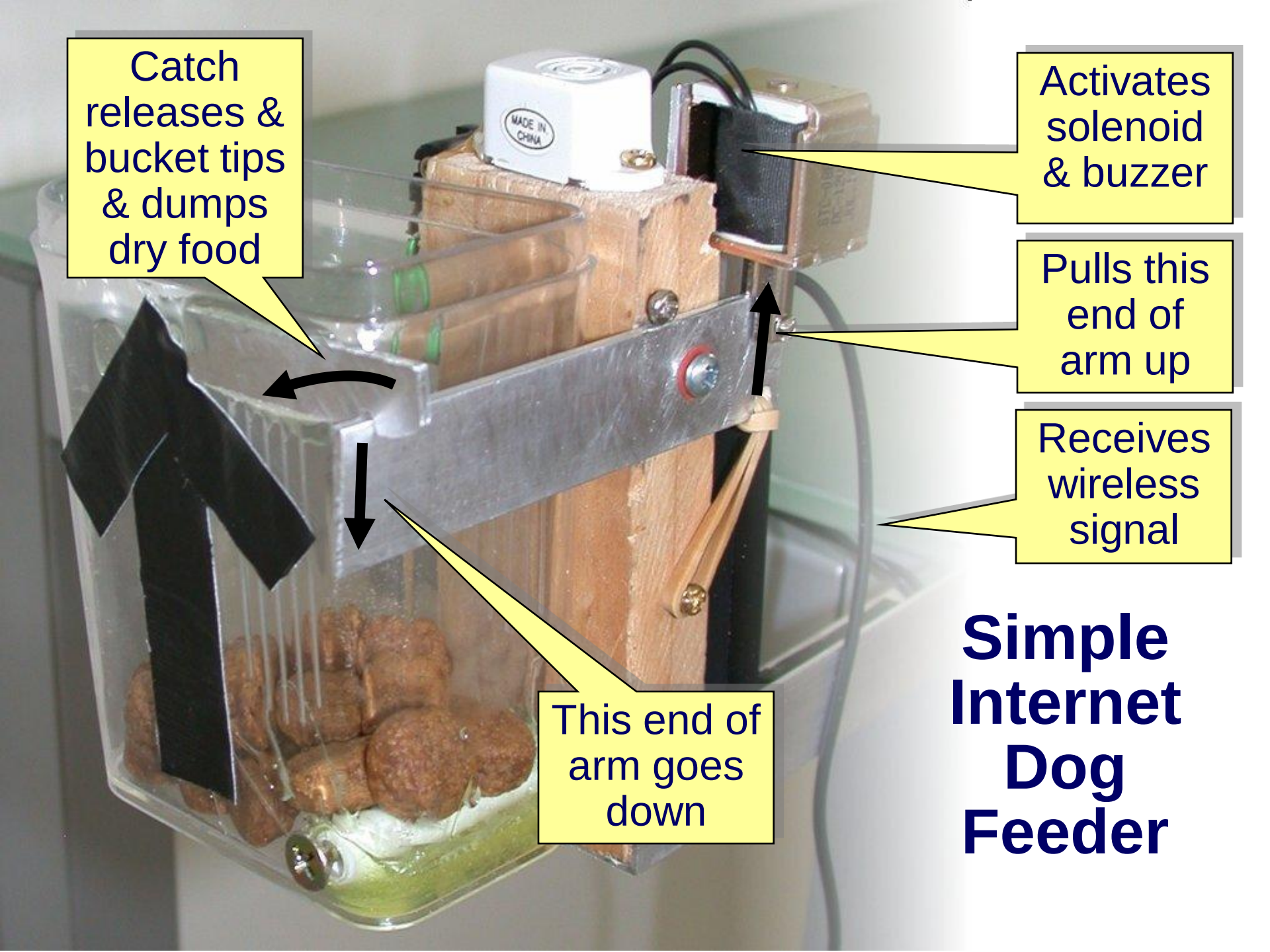
Send

Record on any camera

Alert others by SMS

Feed the dog

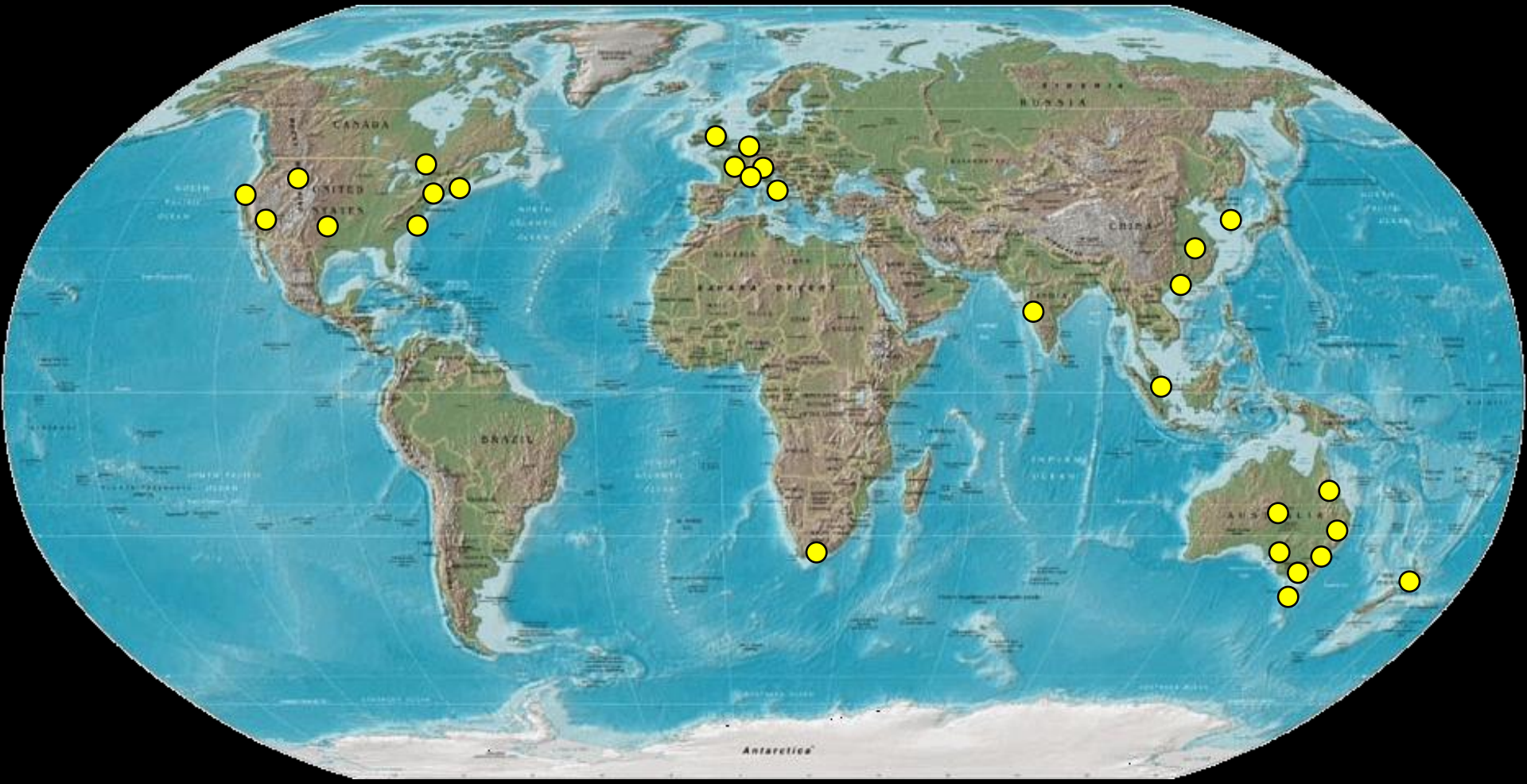
Open garage & record



Simple Internet Dog Feeder

Dog feeder under video surveillance

The World's most Globally-fed Dog?



Sprung!

Caught in the act of trying to guess the password for the dog feeder

(nobody knows you're a dog on the Internet!)

Think about the possibilities in areas like aged care!

(helping older people to live safely at home for longer)

Video Conferencing

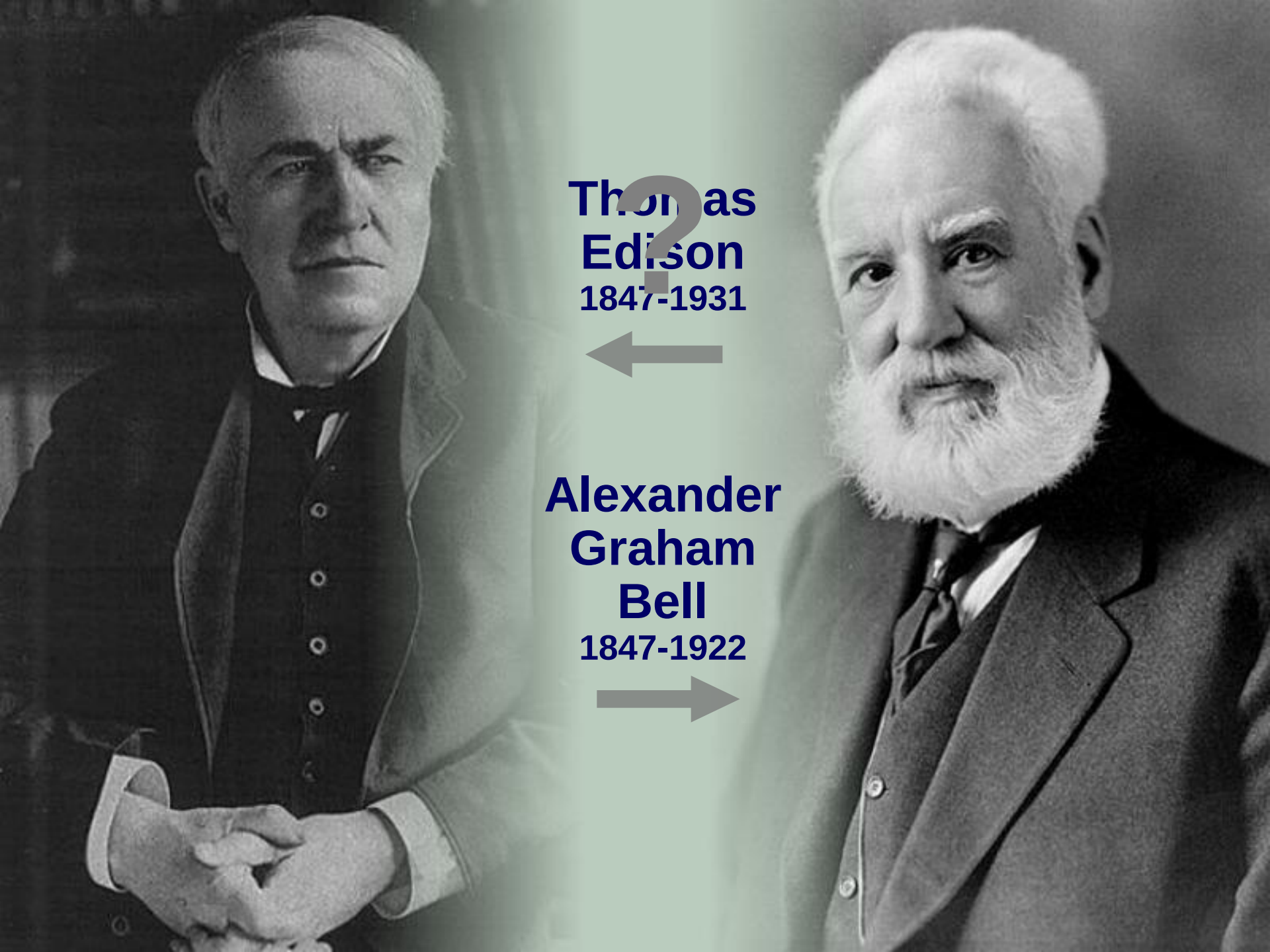
An enhanced communications experience, but it needs:

- **speed**
- **symmetric bandwidth**

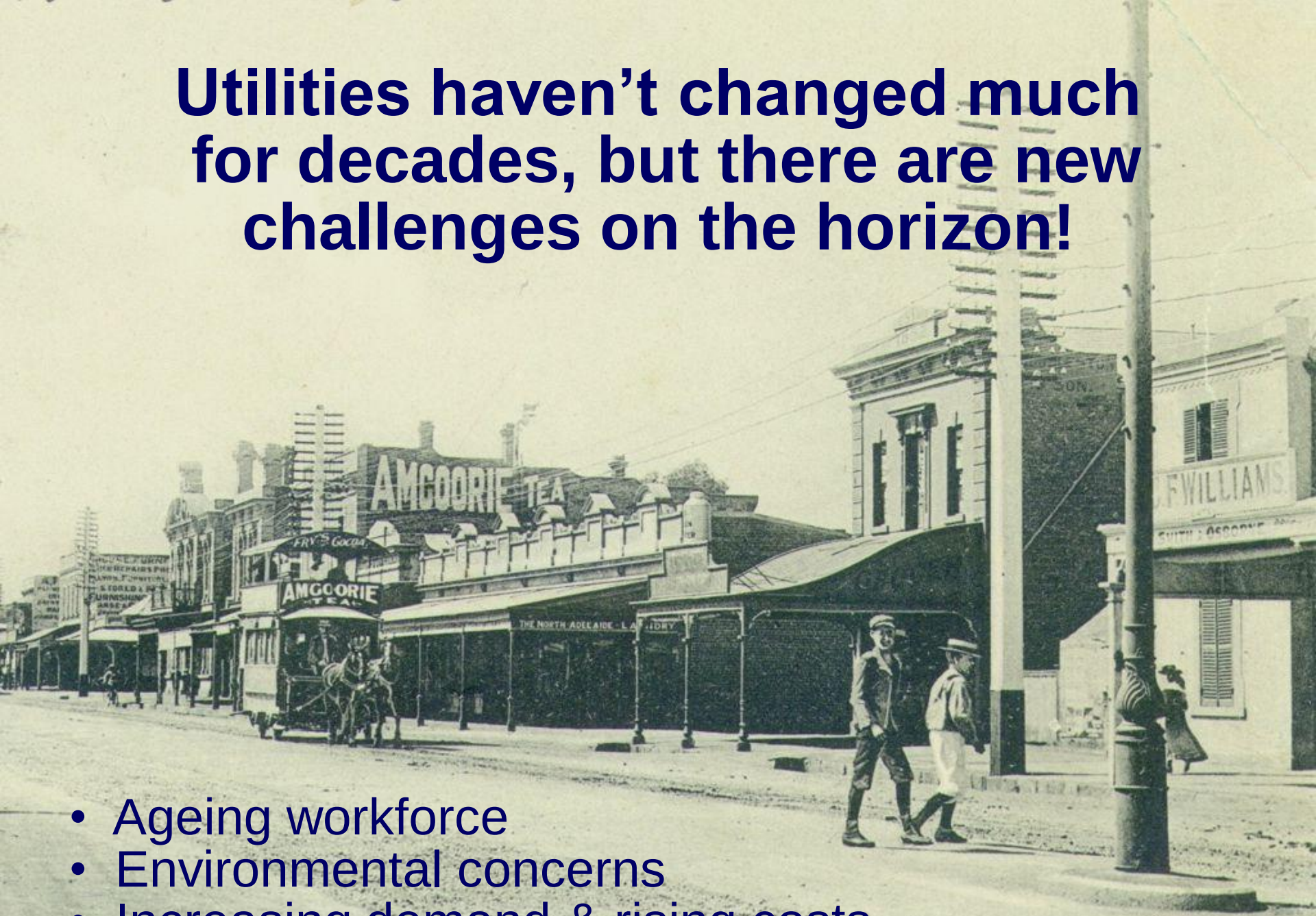
High-end “Tele-Presence”

Dare to imagine that the “high end” business technology of today might filter its way down to consumer use tomorrow!

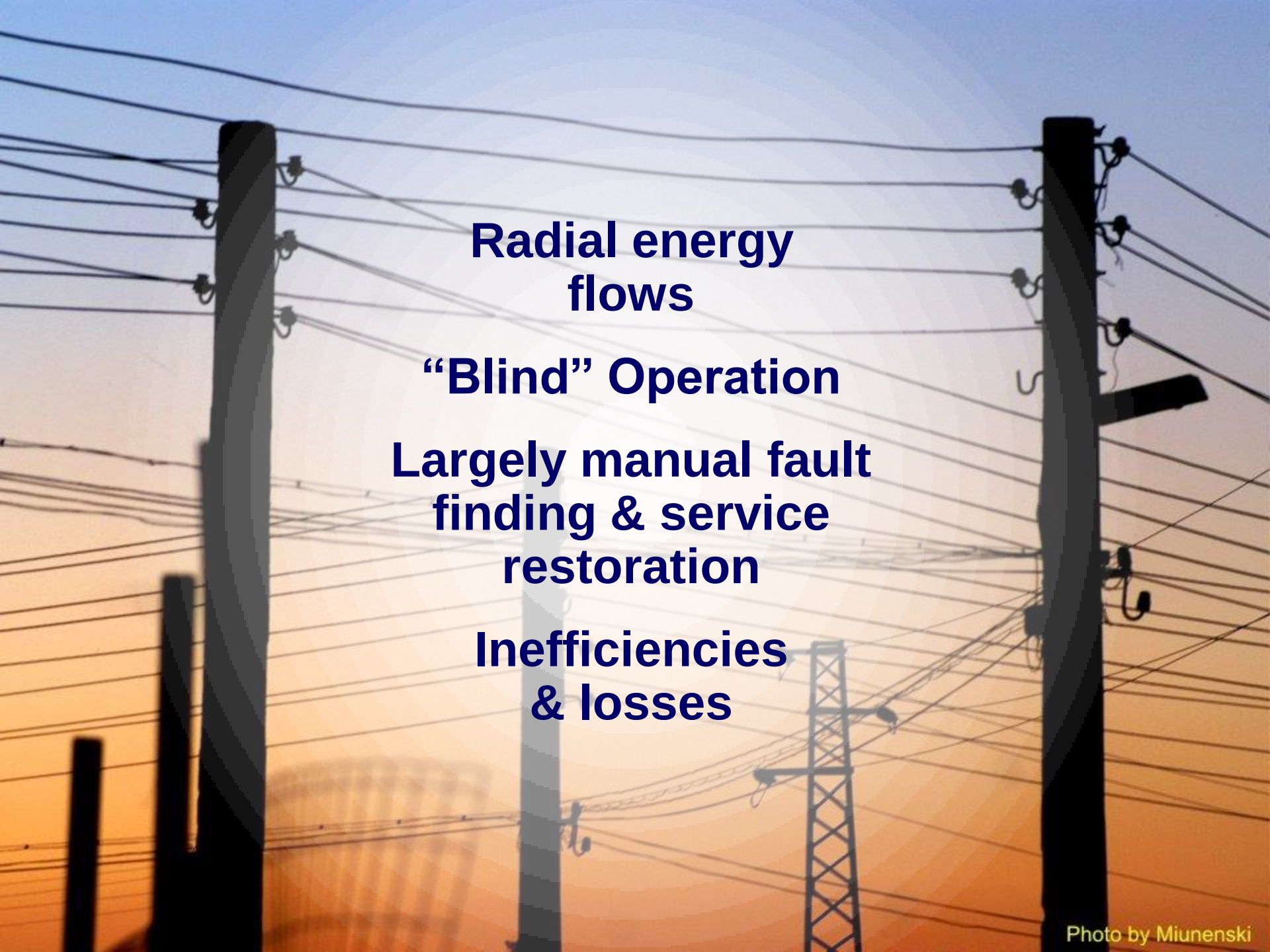
Photo courtesy of cisco


?
Thomas Edison
1847-1931
Alexander Graham Bell
1847-1922

Utilities haven't changed much for decades, but there are new challenges on the horizon!

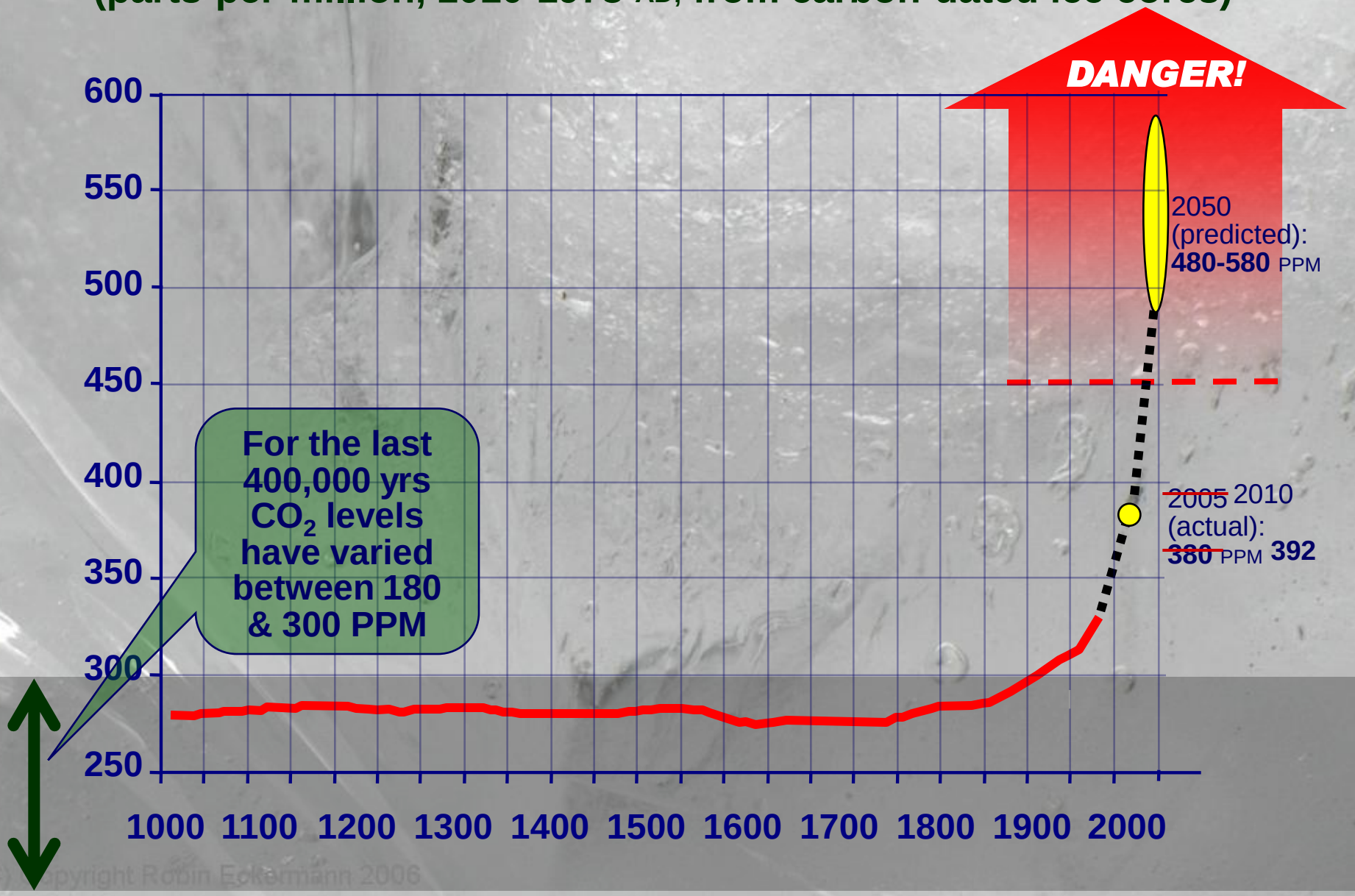


- Ageing workforce
- Environmental concerns
- Increasing demand & rising costs

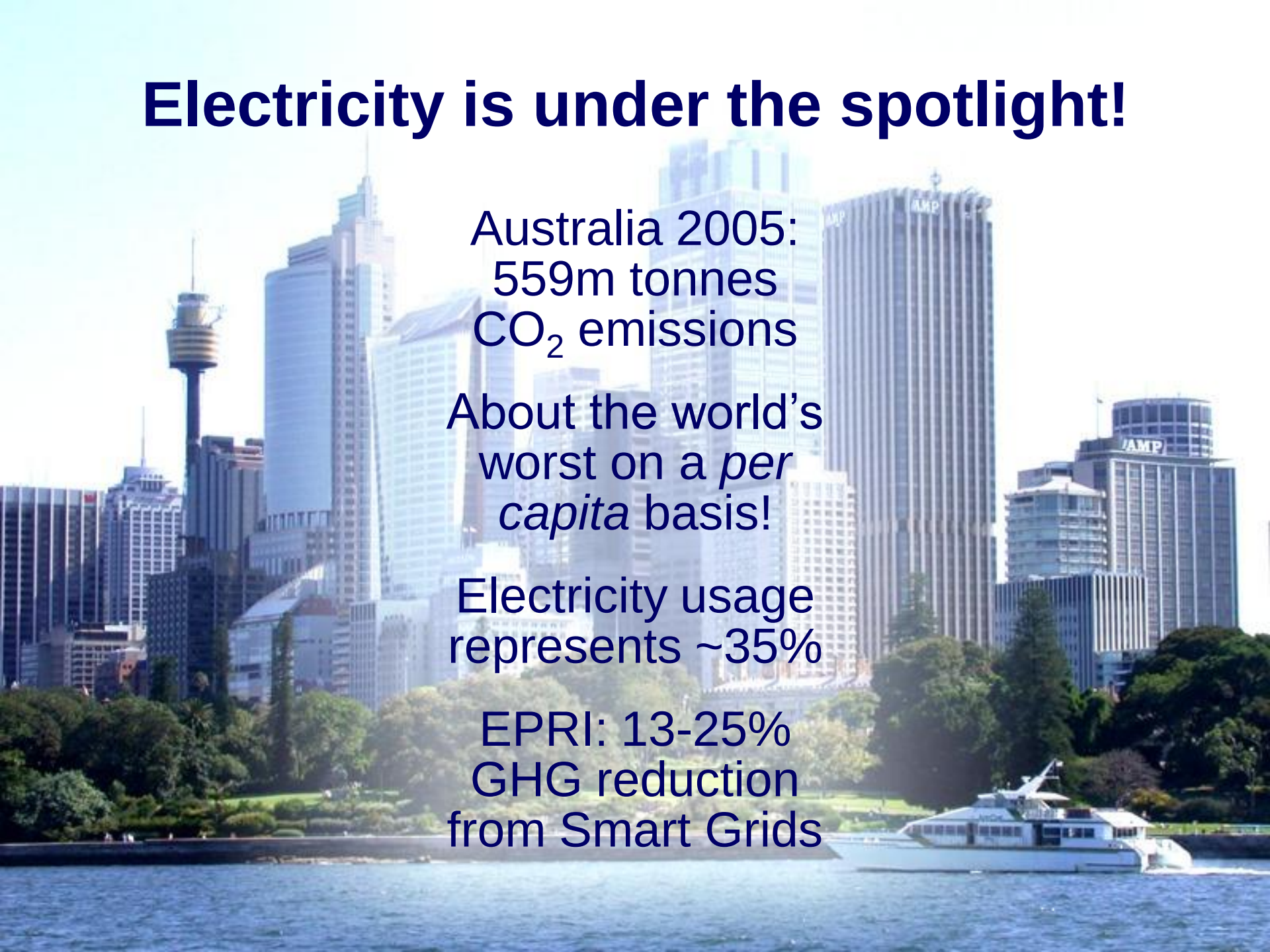

Radial energy flows
“Blind” Operation
Largely manual fault finding & service restoration
Inefficiencies & losses
Photo by Miunenski

Atmospheric CO_2 Concentrations

(parts-per-million, 1010-1978 AD, from carbon-dated ice cores)



Electricity is under the spotlight!



Australia 2005:
559m tonnes
CO_2 emissions

About the world's worst on a *per capita* basis!

Electricity usage represents ~35%

EPRI: 13-25% GHG reduction from Smart Grids

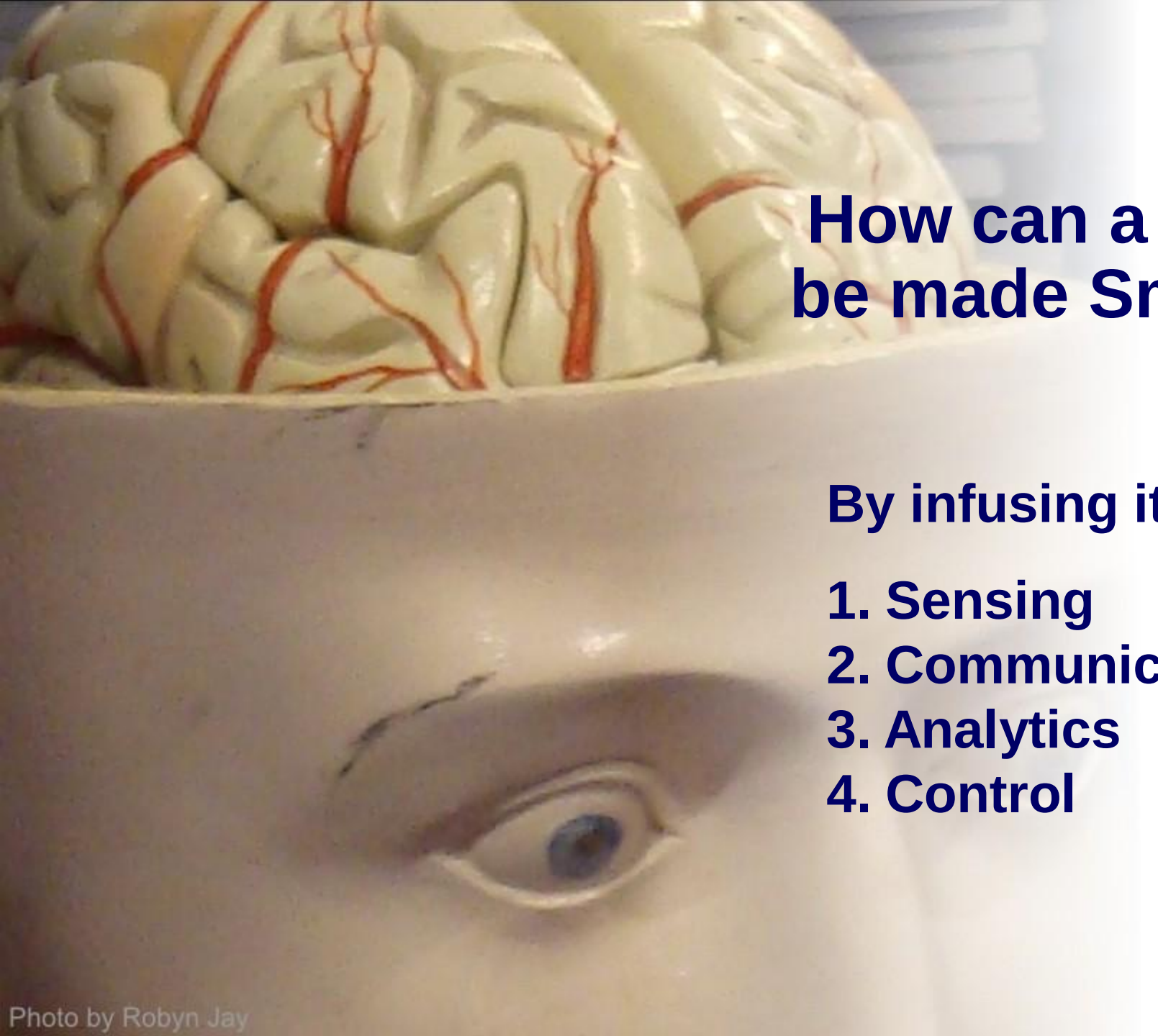
1989 BMW 535i

3.4 litres
155 kW
0-100 km/h in 8.6s
12.3 l/100km

2007 BMW 525i

2.5 litres
160 kW
0-100 km/h in 7.9s
9.4 l/100km

Smart engine technology *(embedded micro-computers & communications)* **accounts for most of the improvement**



How can a Grid be made Smart?

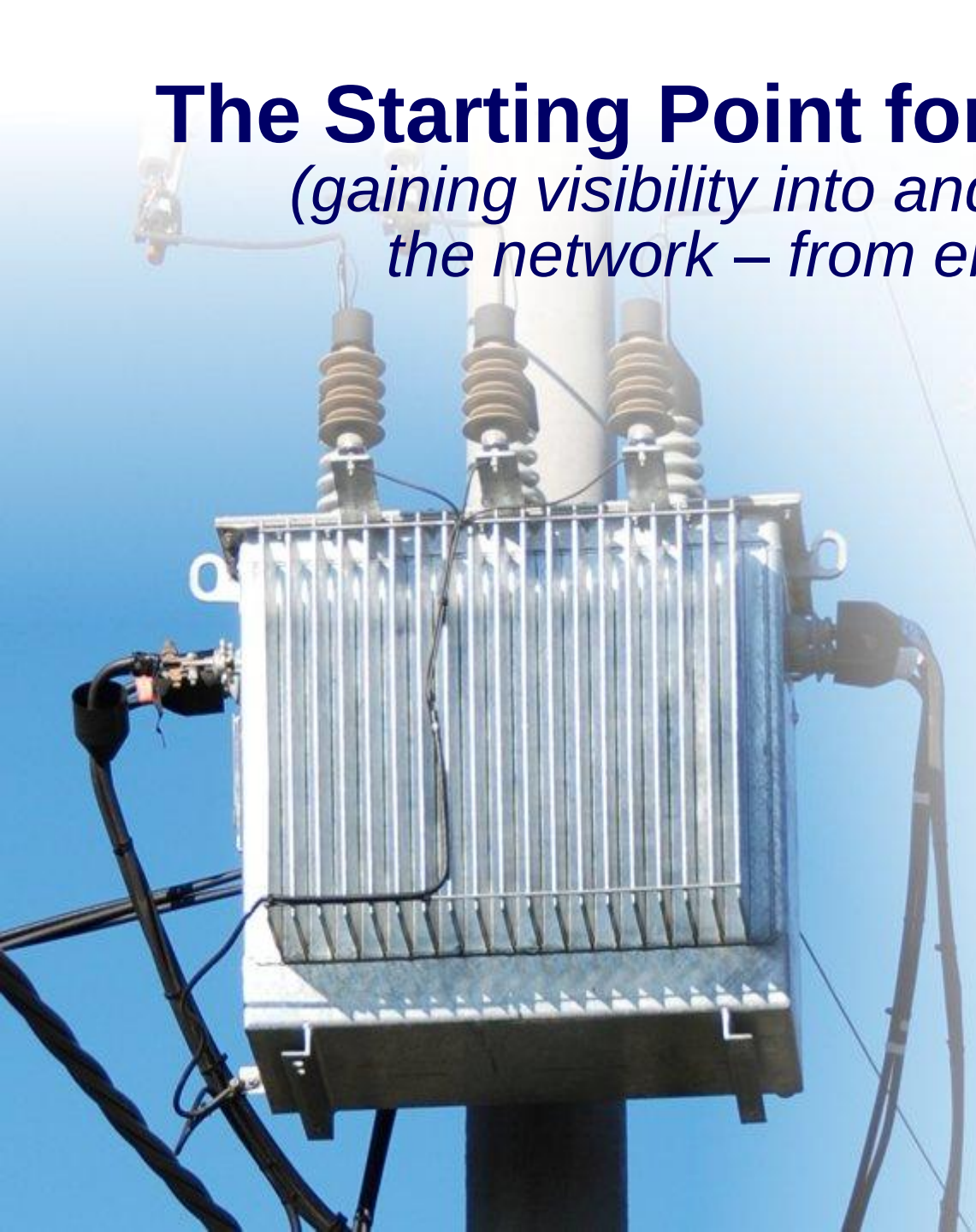
By infusing it with:

1. **Sensing**
2. **Communications**
3. **Analytics**
4. **Control**

Photo by Robyn Jay

The Starting Point for Smart Grids

(gaining visibility into and control over the network – from end to end)



SCADA already exists down to zone substations

Distribution transformers are the next most populous element in the network

Sensing Energy Flows

Rogowski Coil – accurate to 1%

Clamp-on (no outage)

Automatic calibration

current® Transformer Monitoring

Bolt-on device with:

- Processor
- Low & medium voltage Sensing
- Upstream comms
- Downstream comms
- Other inputs & outputs

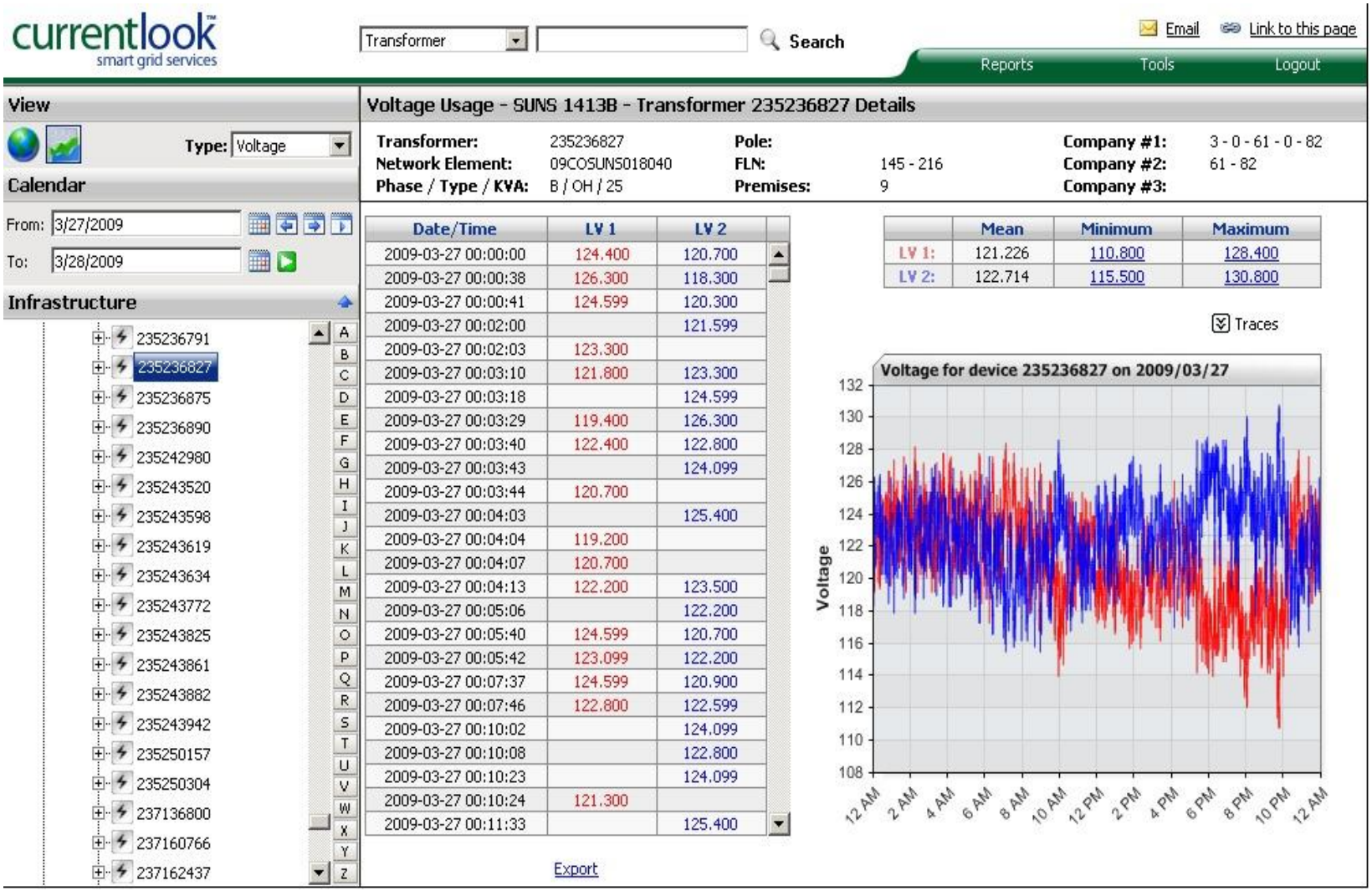
Upstream Communications
(from the transformer)

Horses for courses
(no silver-bullet solution)

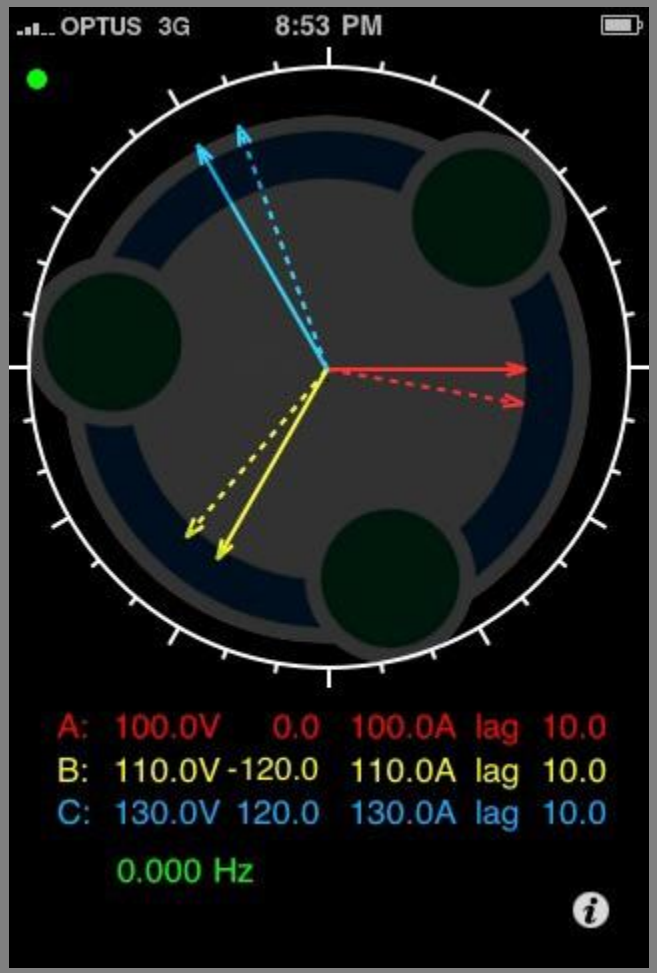
Options include
- Optical Fibre (NBN?)
- Wireless (WiMAX, 3G)
- Ethernet (xDSL)
- MV BPL

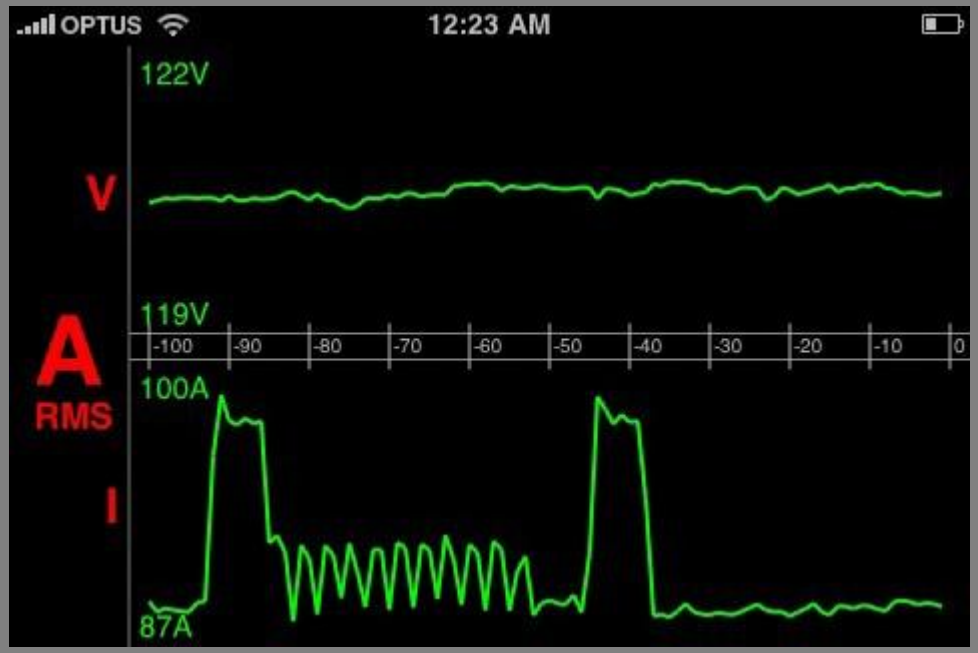
Photo by Tsutomu Takasu

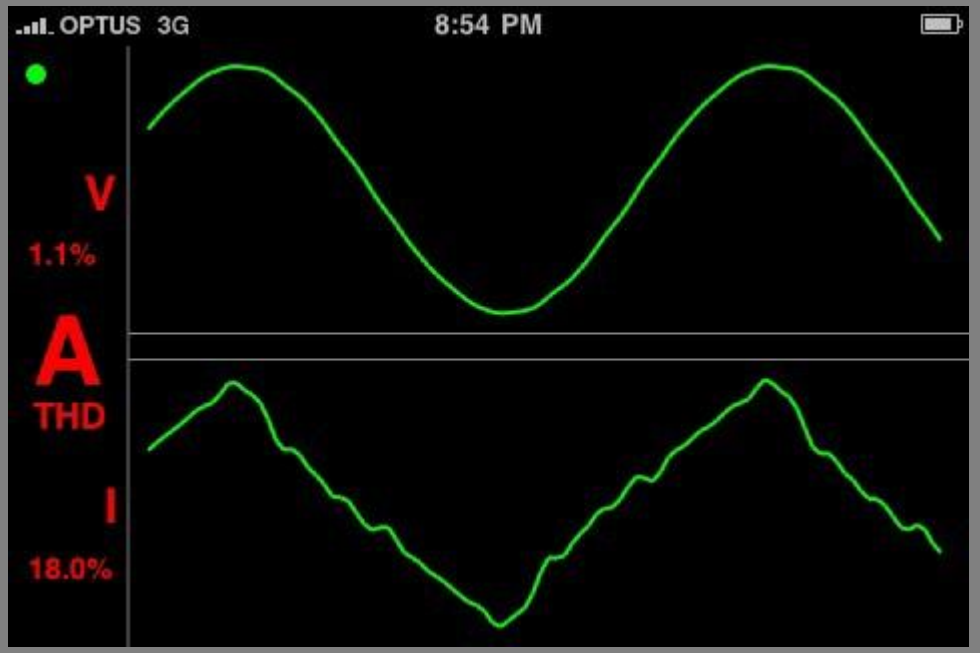
current® Central Systems



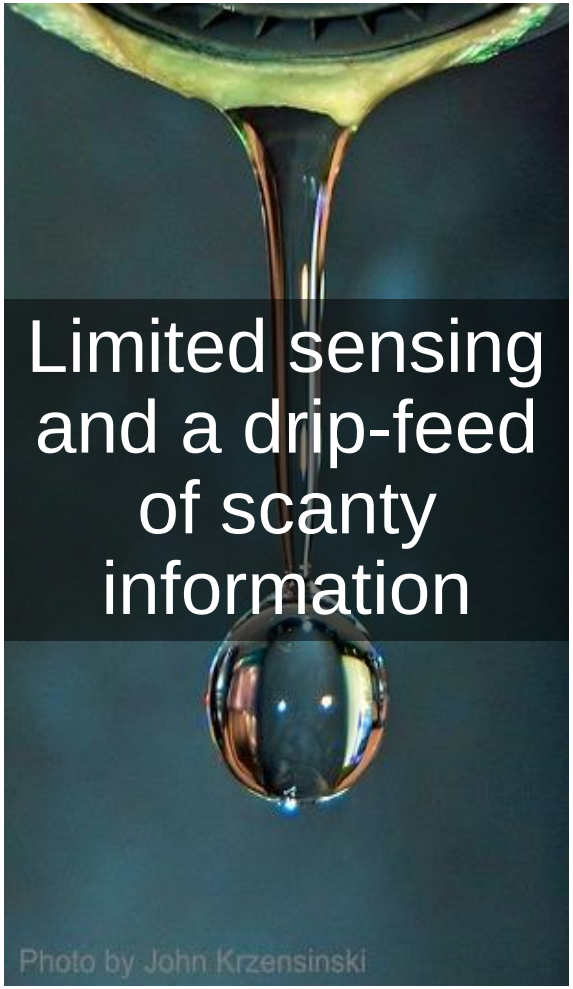
Portable Monitoring

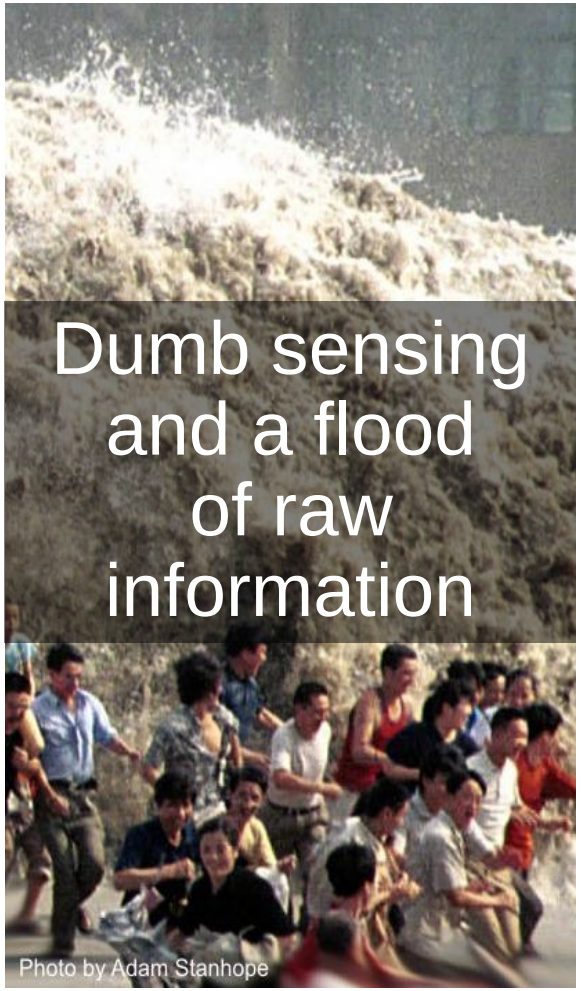






Communication requirements are influenced by the approach





Critical Requirements for SG Communications Fabric

Reliability and Security

Picture by Chris He

Low Latency

Load-handling Capacity

The Benefits

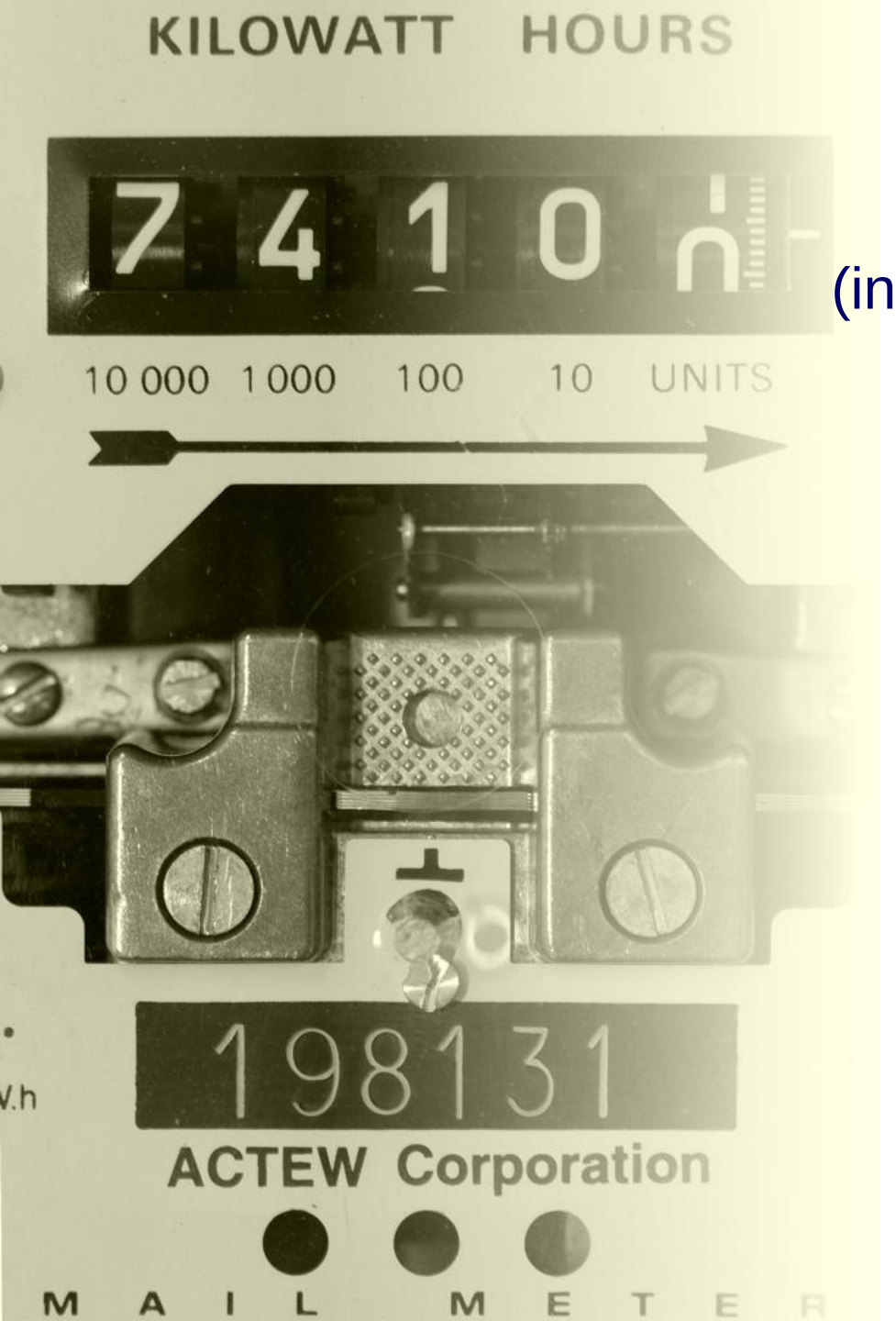
(from the upgrades discussed thus far)

Grid Optimisation

- Conserve voltages, balance phases, reduce losses
- 3-5% saving in power & associated carbon
- no change in user behaviour required

Distribution Monitoring & Control

- Immediate fault recognition & root cause analysis
- Location pin-pointed, crews sent with right equipment
- Repairs verified before leaving the site
- Equipment operated within tolerances, extending life
- Looming failures predicted and avoided



Next comes the meter!

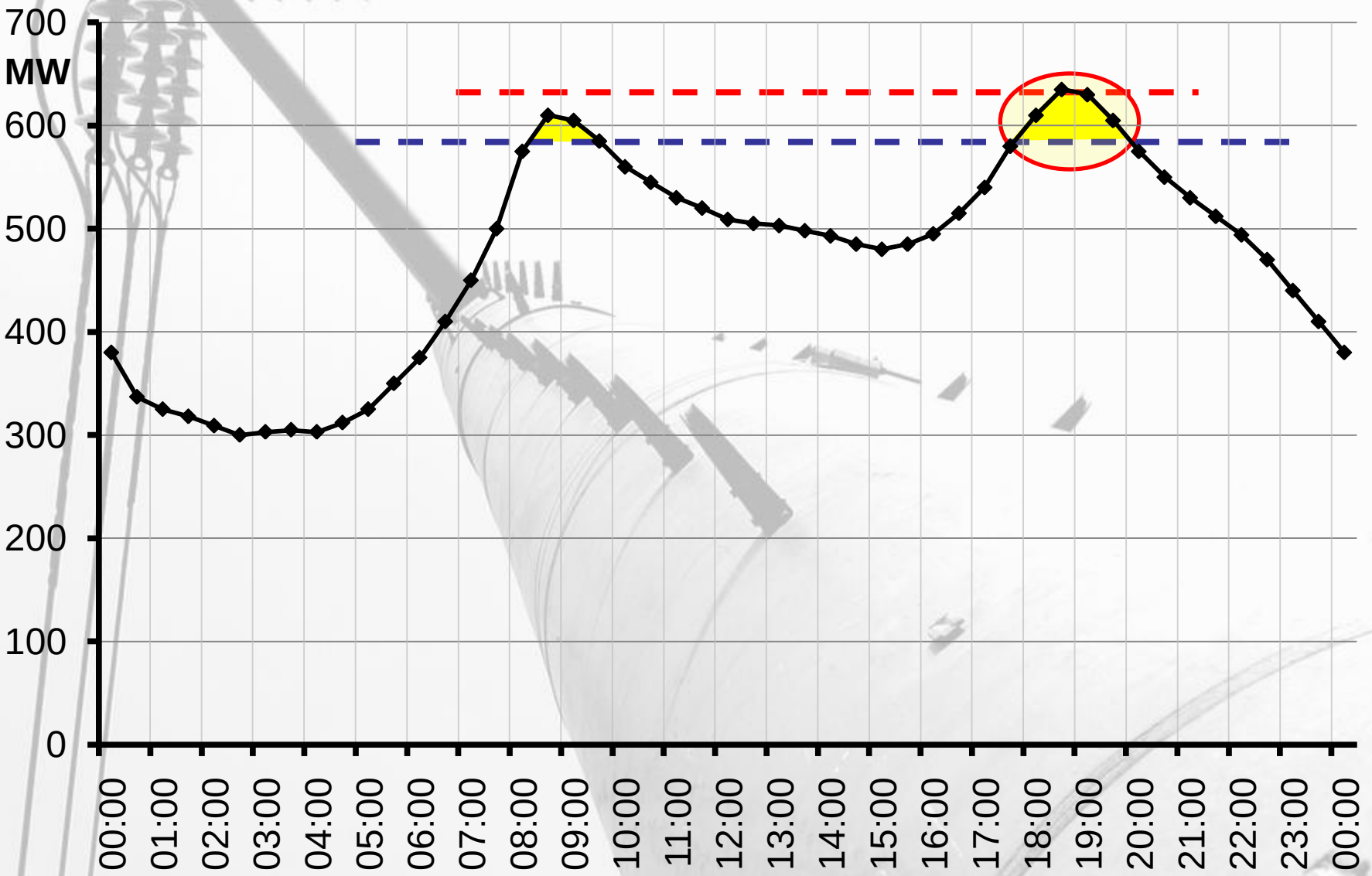
(in extending visibility & control)

Critically located at the point of interface between the grid and the consumer's world

Most expensive element to replace

Central role in Demand-Response

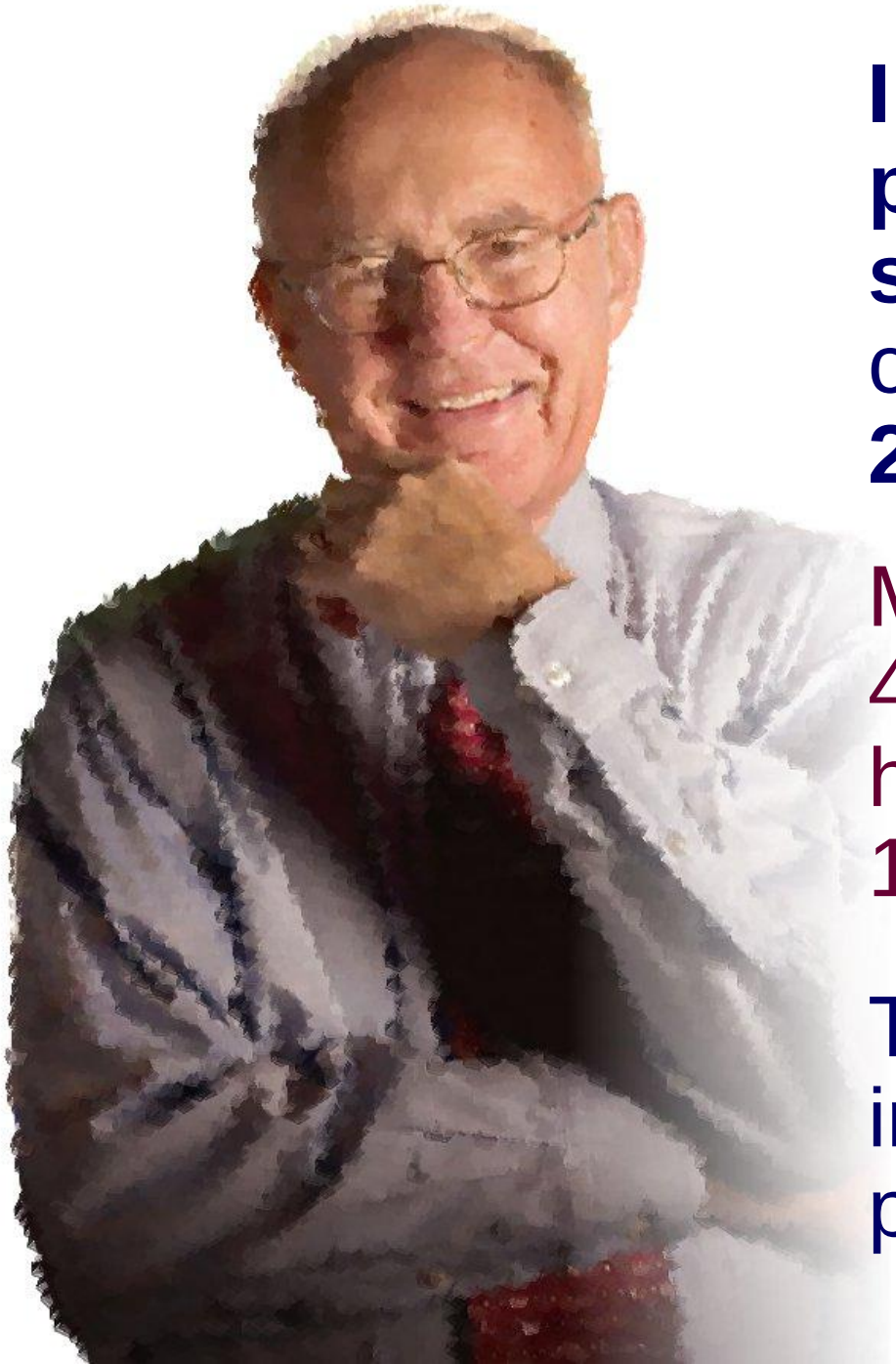
Designing & Building for Peaks



“Smart Meters”

(Advanced Metering Infrastructure)

Time-of-day pricing to change human behaviour & discourage discretionary use during peak periods

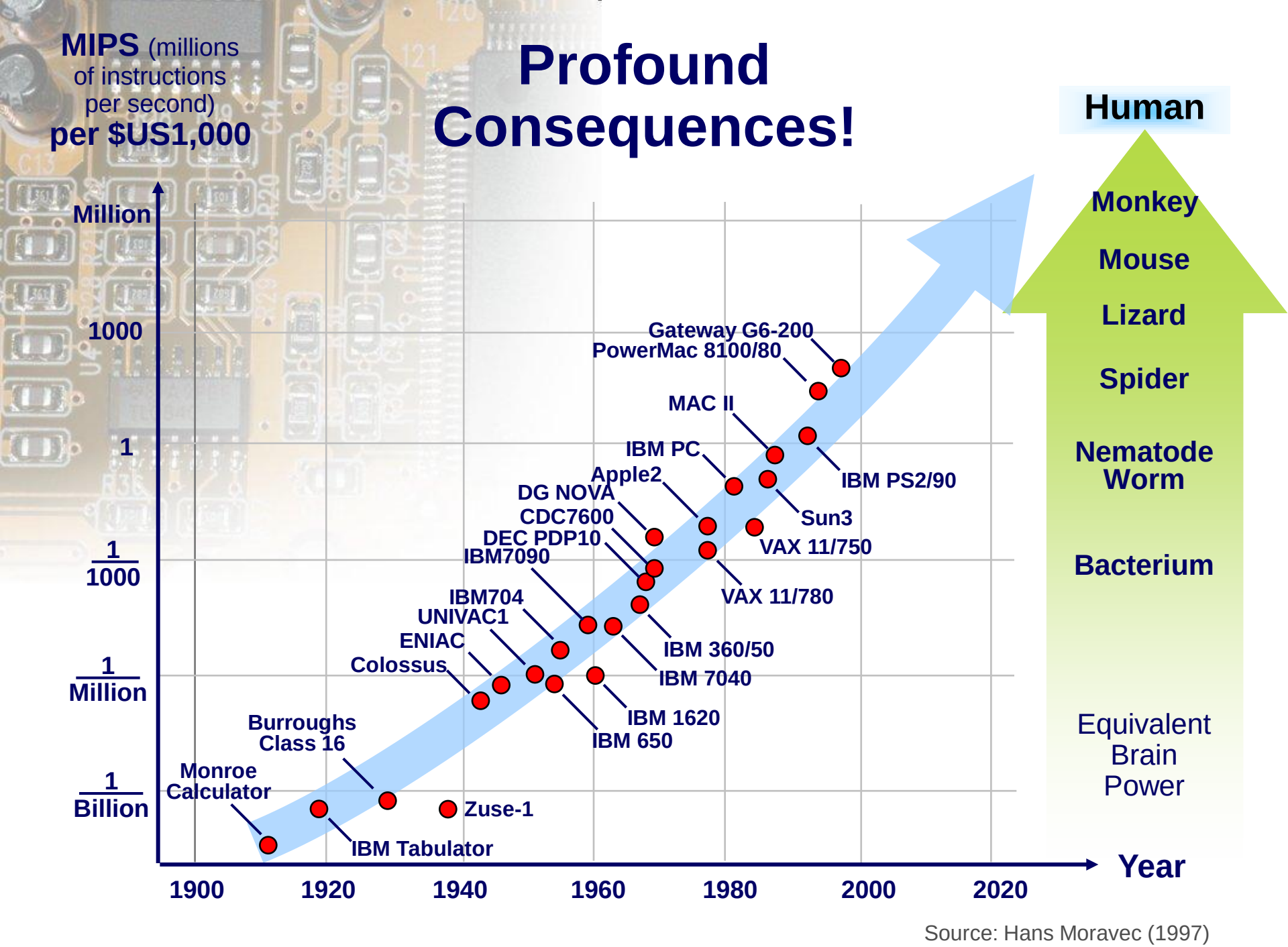


In 1965 Gordon Moore predicted a doubling of silicon densities (and computing power) **every 24 months**

Moore's Law is now 45 years old and power has been doubling every 18-24 months

That's >100 million fold increase in computing power over the period!

Profound Consequences!



Source: Hans Moravec (1997)

Over the Horizon

In 15 yrs
a 1000-fold
increase in
ICT power

Smart
digital
appliances

Focus
on energy
management

Photo by Martin Charboneau

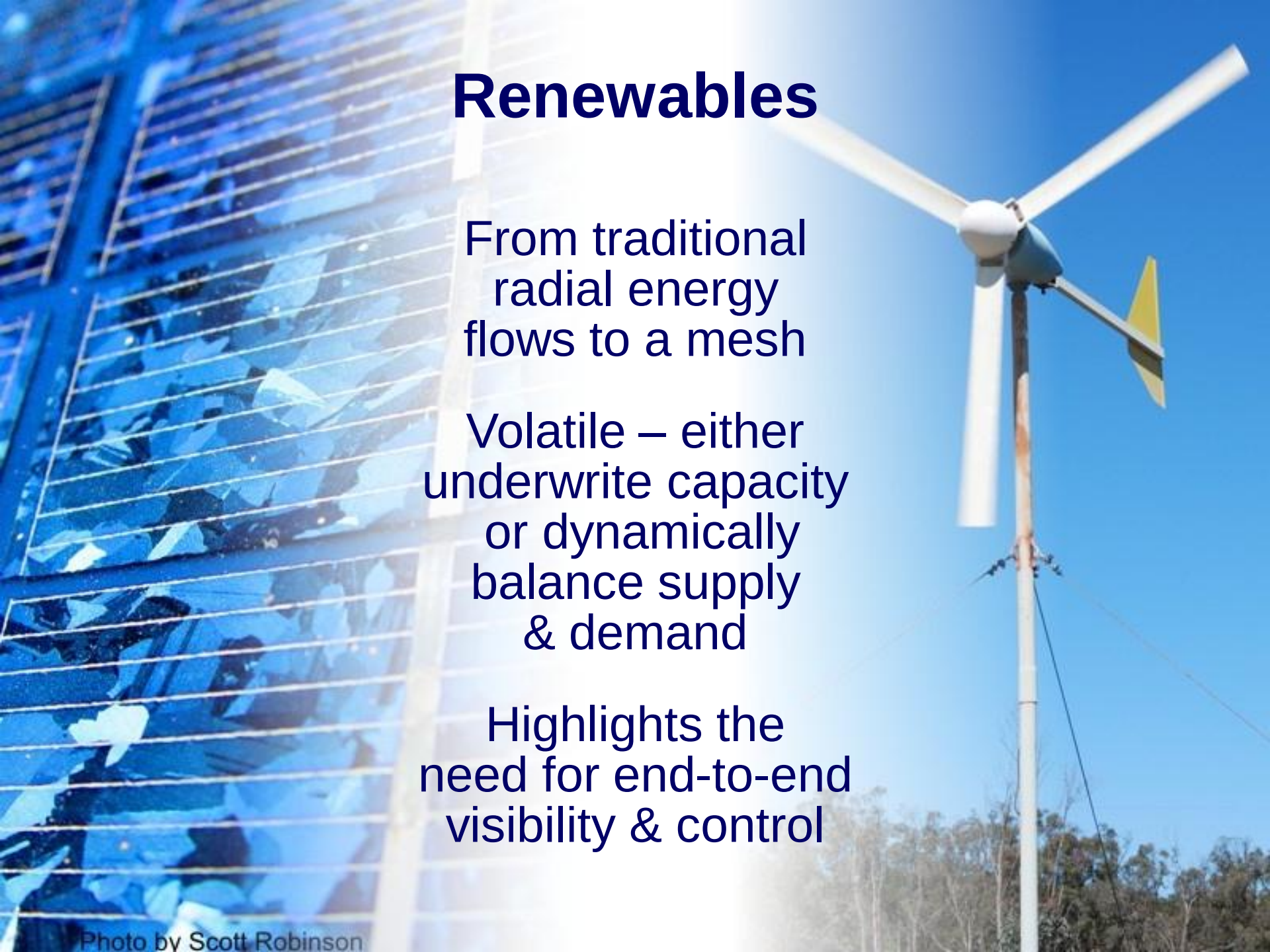
Photo by Pjen

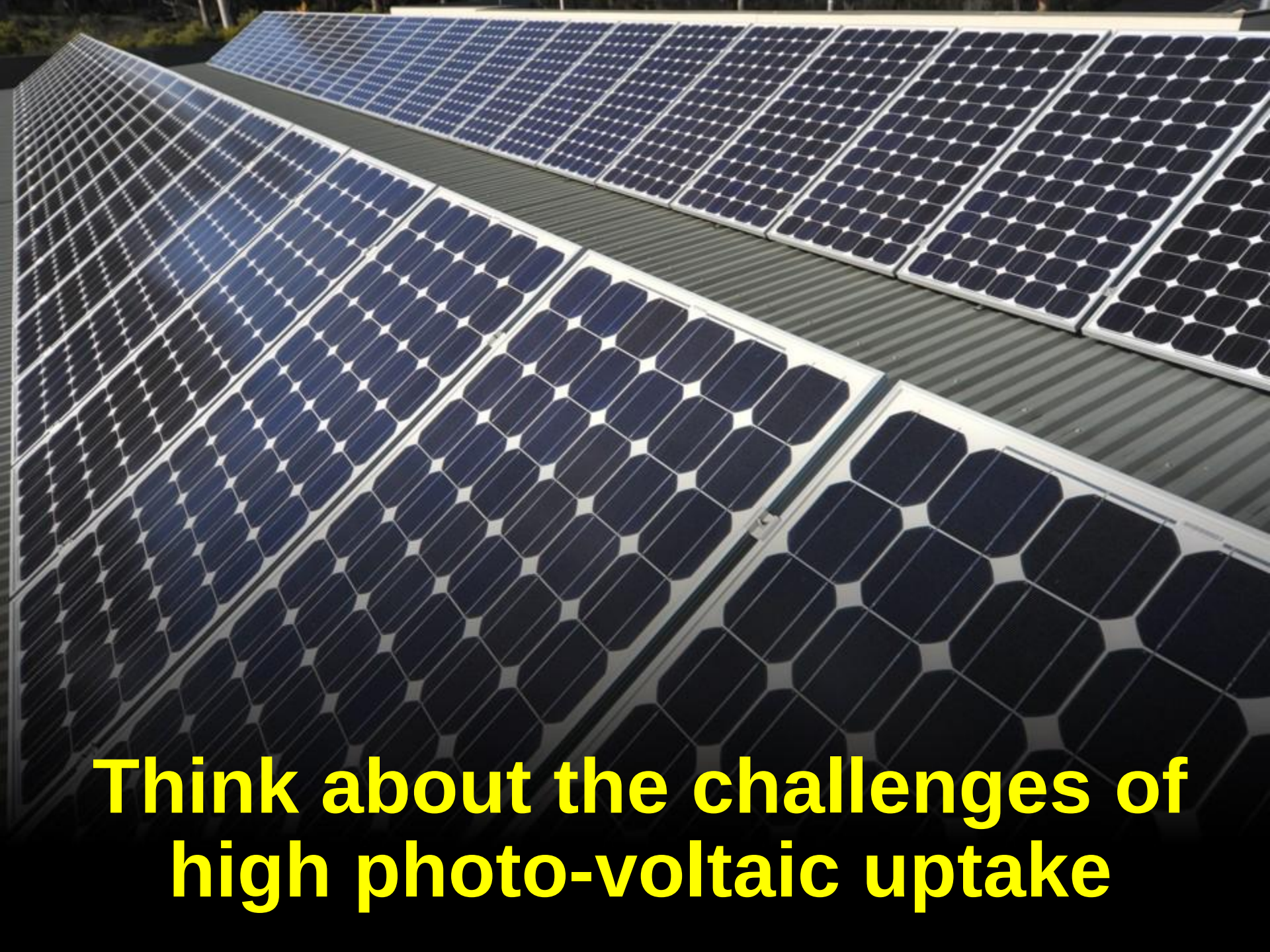
Renewables

From traditional radial energy flows to a mesh

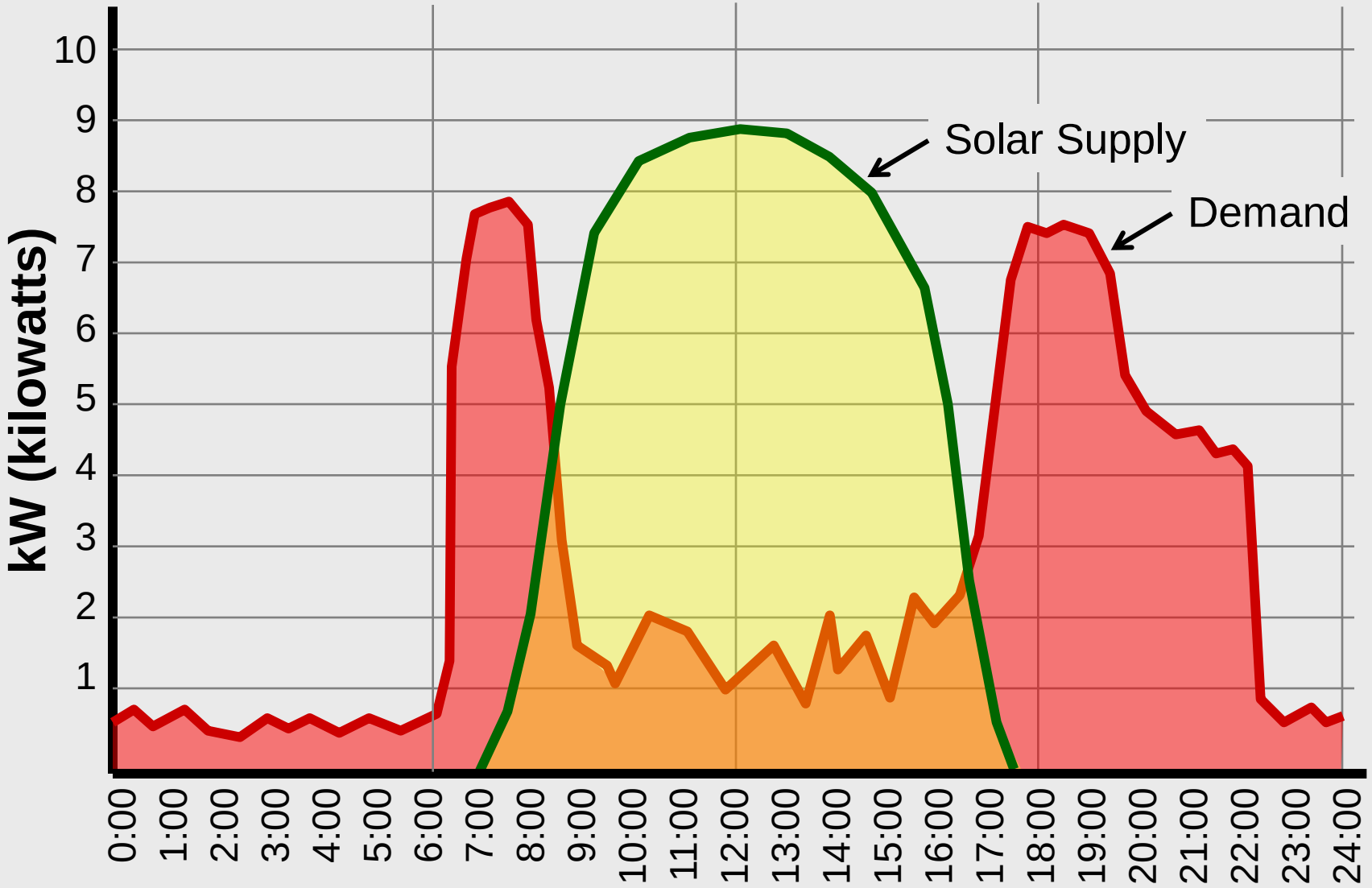
Volatile – either underwrite capacity or dynamically balance supply & demand

Highlights the need for end-to-end visibility & control




Think about the challenges of high photo-voltaic uptake

“Hotspots” where supply>demand!

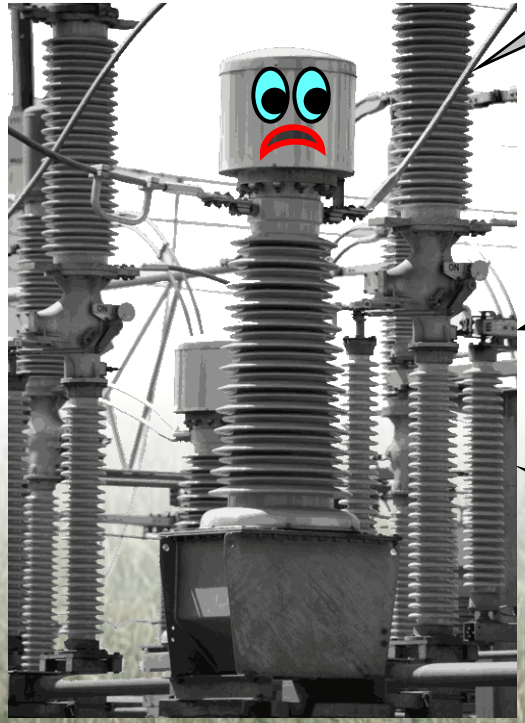


Huge opportunities with emerging appliances like plug-in electric vehicles

- Latitude in the timing of overnight recharging
- Huge, distributed energy store for the grid
- Needs communications!

Original photo by Bill Liao (see http://www.flickr.com/photos/liao/1620347221/)

The Grid



Things are starting to run hot here! Can you pause recharging?

Sure! I've got nothing on for the next 8 hours

Its just gone from bad to worse. I'll offer $0.50 per kWh for anything you can give me …

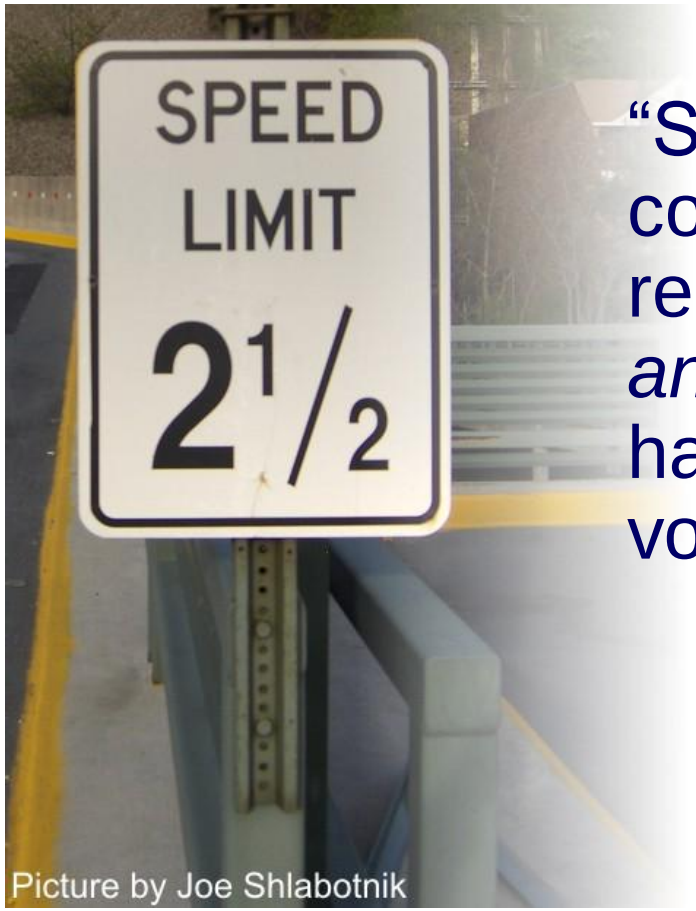
No deal!

I'm desperate. How about $1.00/kWh?

OK … it's Tuesday, so you can have 10 kWh and that will still leave me enough energy to get home after work

Plug-in Electric Vehicle

The communication requirements of a Smart Grid start to look very different from those of Smart Meters!



Picture by Joe Shlabotnik

"Smart Meters" using comms solutions lacking real-time performance *and* the capacity to handle flurries of high-volume traffic will either:

- limit progress or
- need upgrading!

Smart Meters

Enabler or blocker?

Questionable effectiveness of pricing signals

Limited comms requirements

Risky to start replacing meters ahead of SG plan!

Picture by Pete Reed

Potential to use the National Broadband Network?

No questions about technical capability

Pragmatic issues:

- Location of Optical Network Termination (ONT)
- ONT powering
- ONT connection
- Customers with no other NBN services

In-grid alternatives may prove easier (eg: PRIME)

Photo by Michael Wyszomierski

Greenfields Opportunity

Brownfields issues resolved by design

Will utilities want to support separate greenfield/brownfield approaches?

Slow attainment of critical mass!

Optical Fibre?

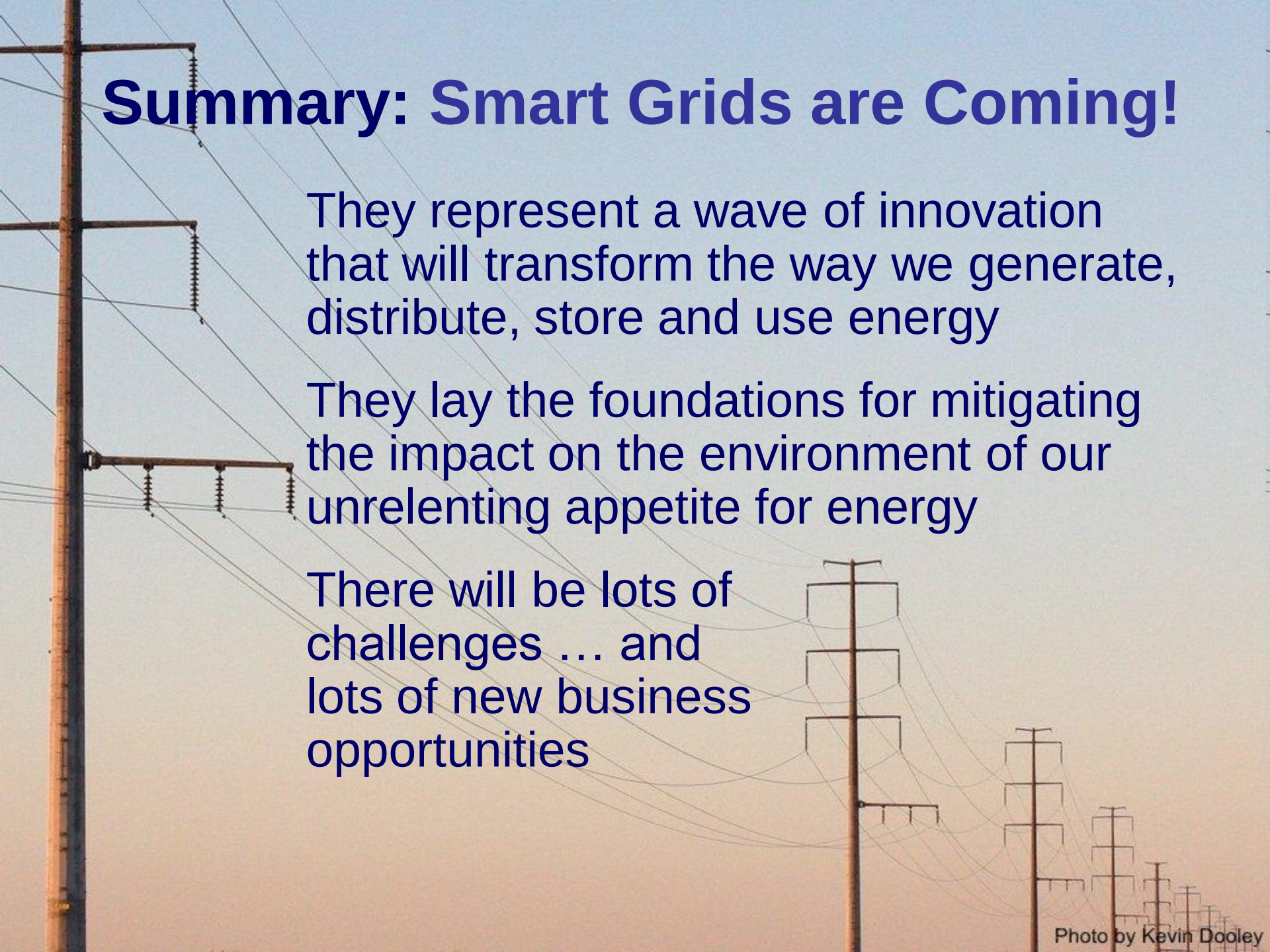
NBN aerial deployment will pass many transformers, and meter and ONT may be as little as 1 metre apart

Summary: Smart Grids are Coming!

They represent a wave of innovation that will transform the way we generate, distribute, store and use energy

They lay the foundations for mitigating the impact on the environment of our unrelenting appetite for energy

There will be lots of challenges … and lots of new business opportunities



Thank You

for allowing me to share these thoughts with you!

Robin Eckermann

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