

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**

Voice-over-IP (VOIP) Telephony

Portable phone number

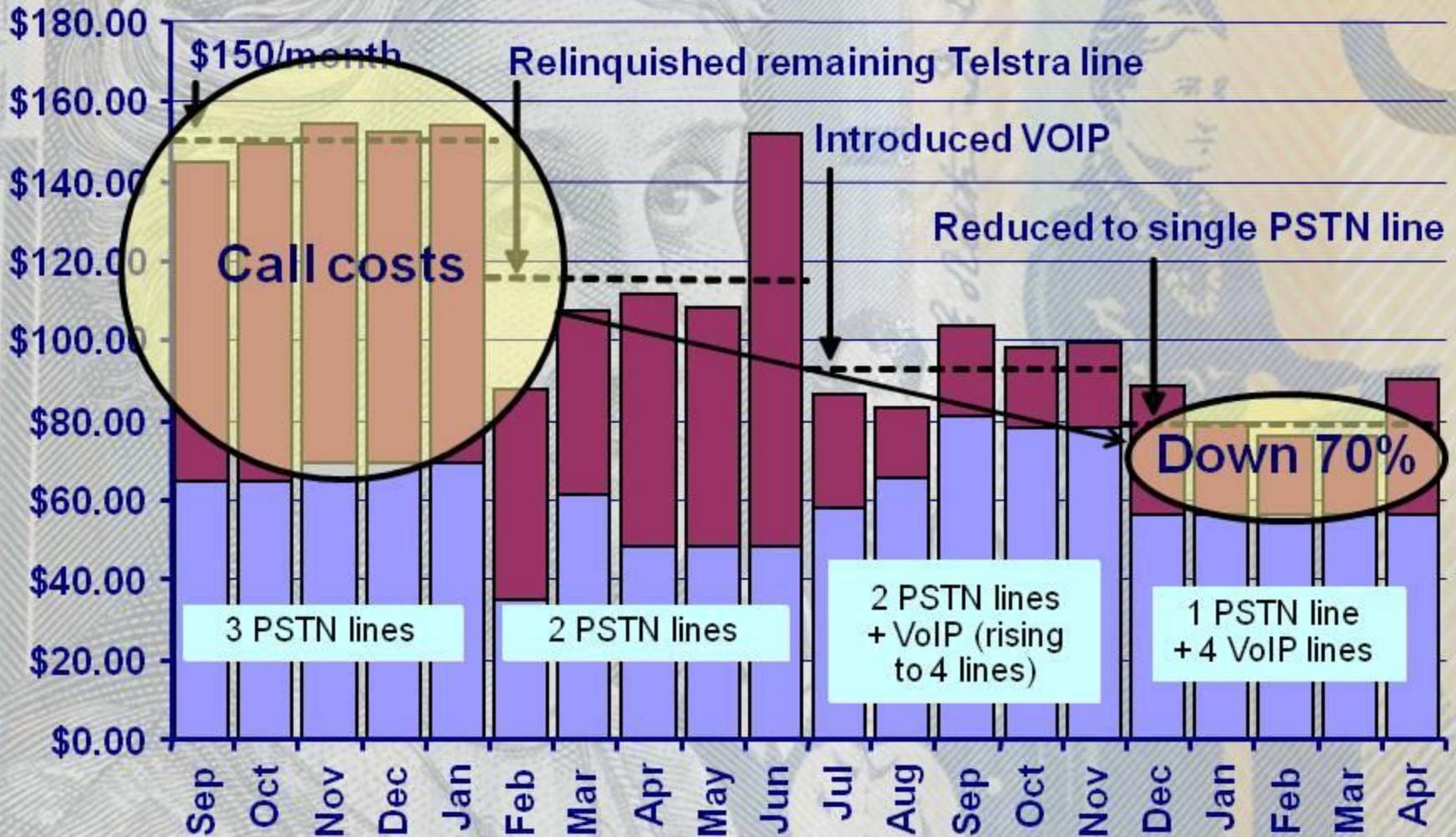
Voice messages forwarded by email

Local numbers interstate & overseas



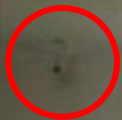
ATA (Analog Telephony
Adapter) interfaces a
conventional phone
to the broadband connection

Big \$avings





MP3 Music



**New &
better
approaches
to old
problems**



**Check the
premises
from
anywhere
in the
world
via the
Internet**

Multi-camera view

- Entrance
- Garage
- Kitchen
- Games Room
- Video All
- configuration



Mobile Phone Access



Record on any camera

Alert others by SMS

Feed the dog

Open garage & record

Send

1 2 3 4

Recording

1 2 3 4

SMS Alerts

R L M J

Control

Feed Seve

Delivery

Garage

Buzz

Send

The screenshot shows a mobile phone interface for remote camera control. At the top is a camera feed of a building entrance. Below the feed is a "Send" button. Underneath are four radio buttons labeled 1, 2, 3, and 4, with radio button 2 selected. This is followed by a "Recording" section with four checkboxes labeled 1, 2, 3, and 4. Below that is an "SMS Alerts" section with four checkboxes labeled R, L, M, and J. The "Control" section includes three checkboxes: "Feed Seve", "Delivery", and "Garage". At the bottom is a "Buzz" section with a checkbox and another "Send" button. Four yellow callout boxes with black borders point to specific features: "Record on any camera" points to the camera feed; "Alert others by SMS" points to the SMS Alerts checkboxes; "Feed the dog" points to the "Feed Seve" checkbox; and "Open garage & record" points to the "Garage" checkbox.

Catch
releases &
bucket tips
& dumps
dry food

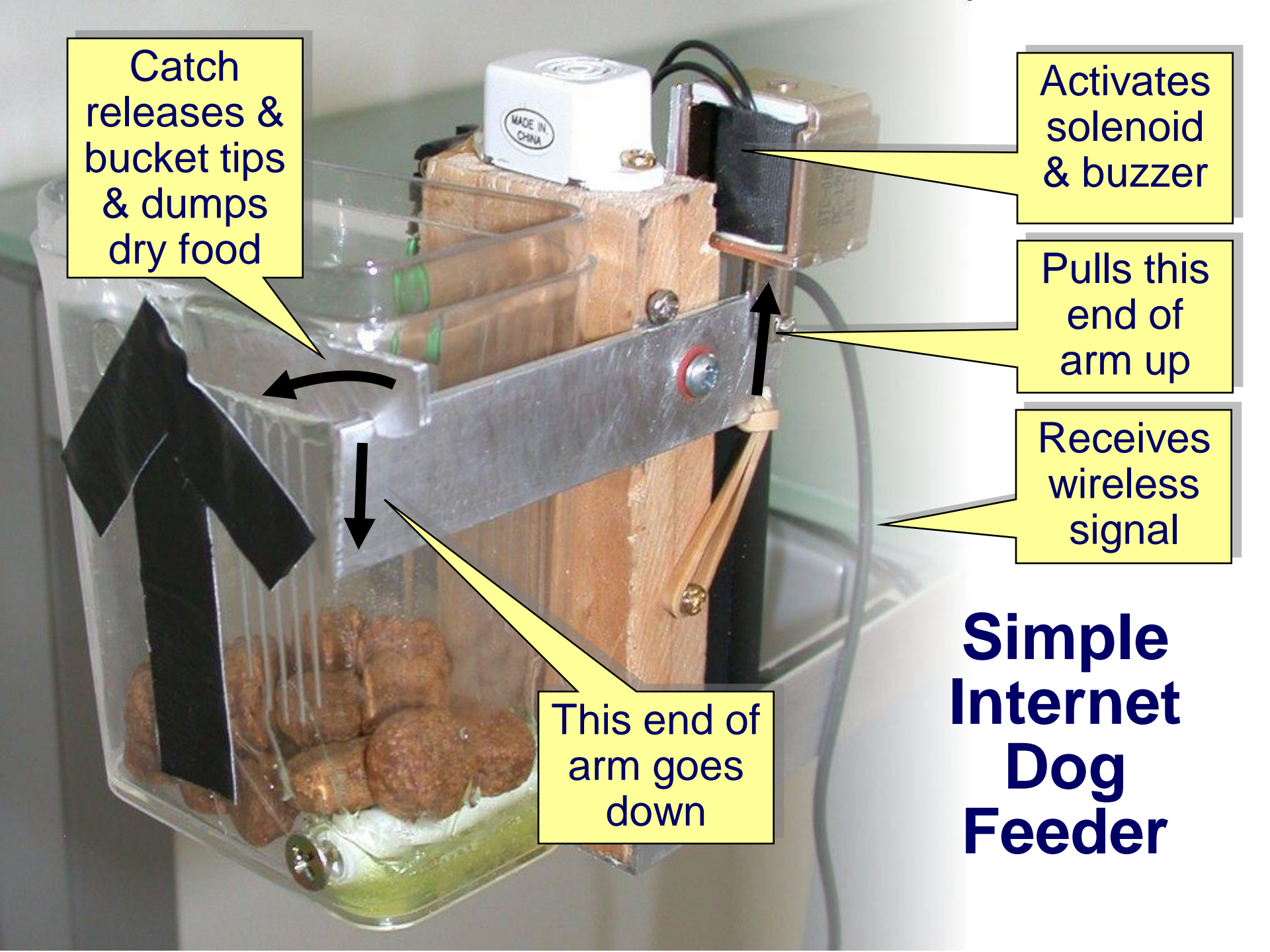
Activates
solenoid
& buzzer

Pulls this
end of
arm up

Receives
wireless
signal

This end of
arm goes
down

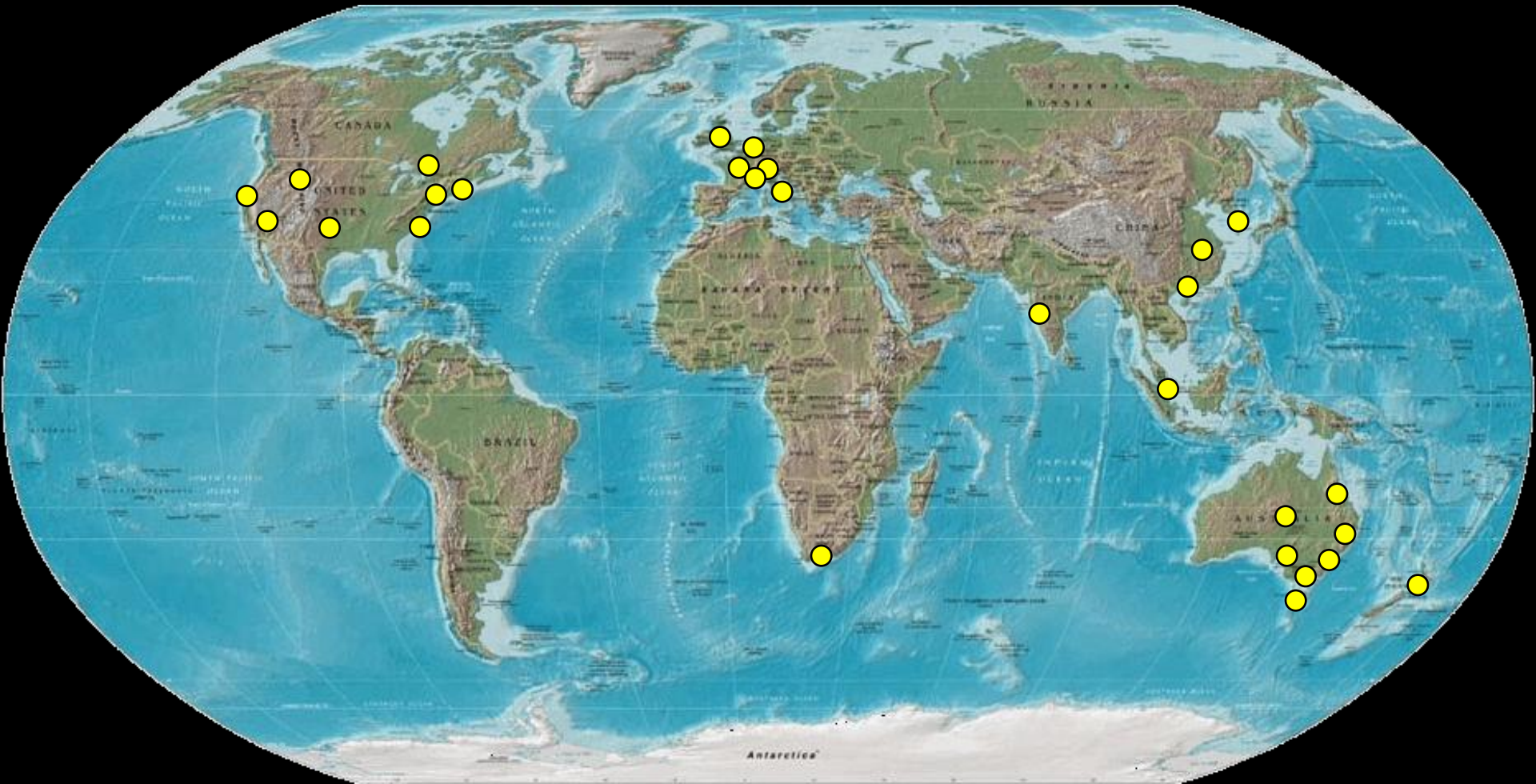
Simple Internet Dog Feeder



**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:

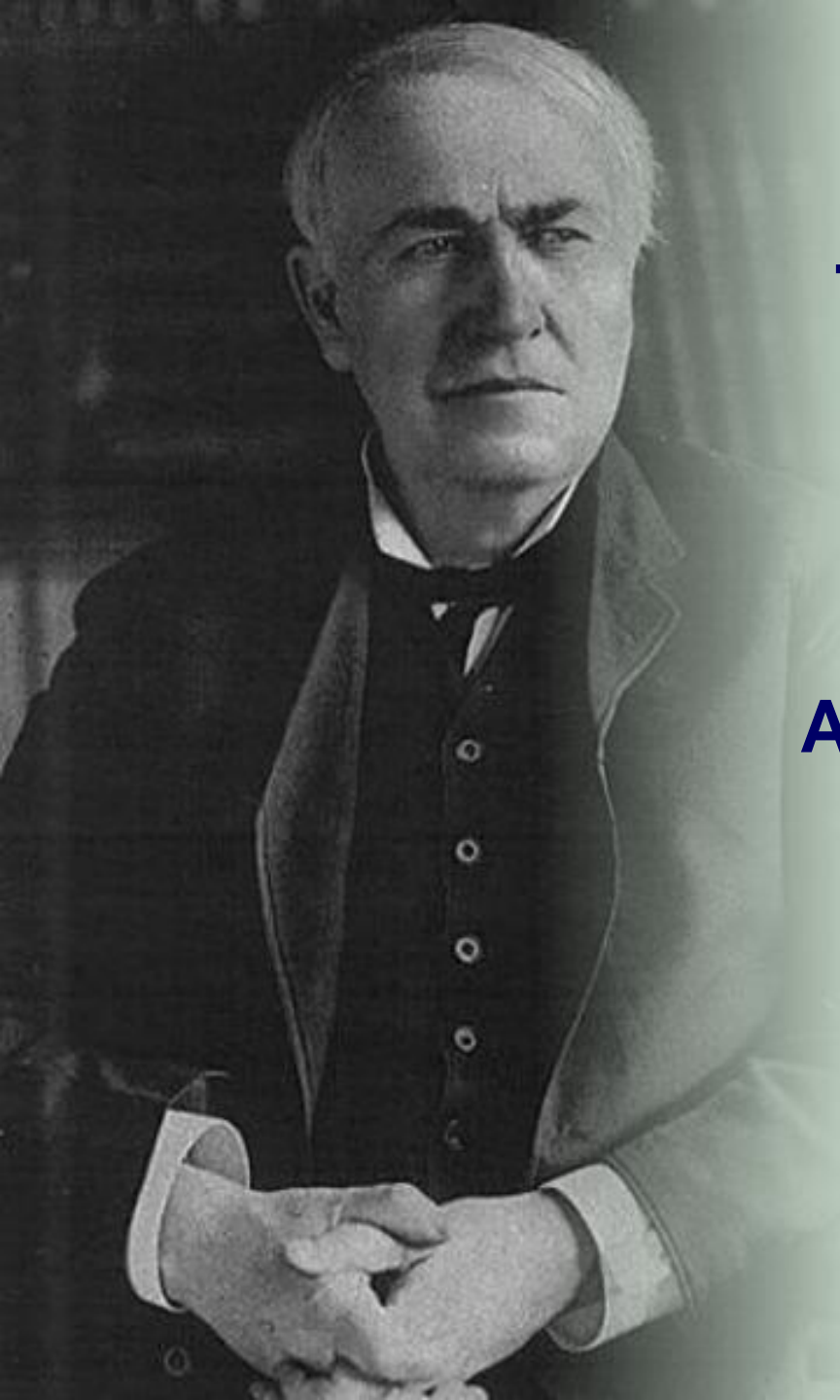
- speed
- symmetric bandwidth



High-end “Tele-Presence”



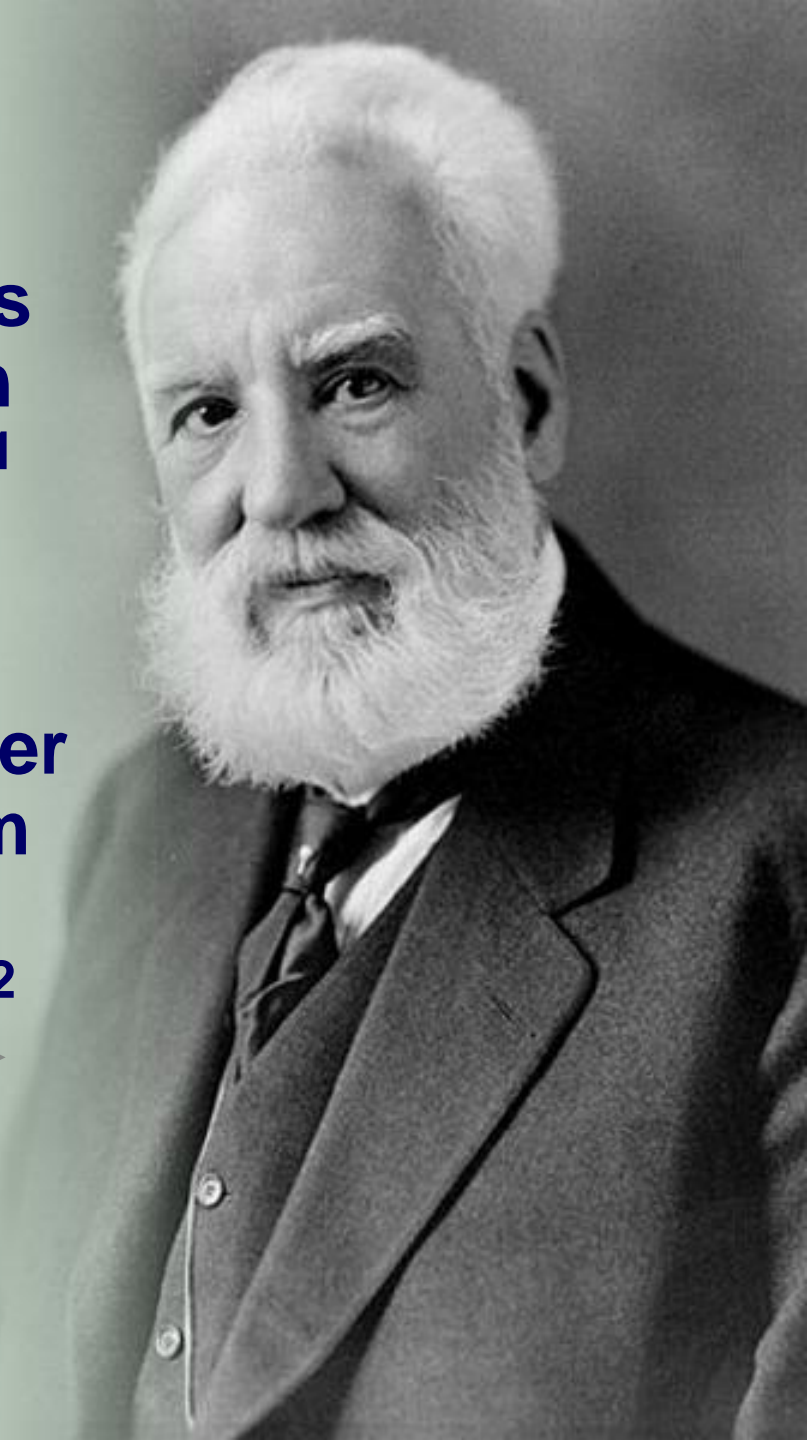
Dare to imagine that the “high end” business technology of today might filter its way down to consumer use tomorrow!



**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

A photograph of a power line tower at sunset. The sky is a mix of blue and orange, with the sun low on the horizon. The tower is a lattice structure, and several power lines are visible. The text is overlaid in the center of the image.

**Radial energy
flows**

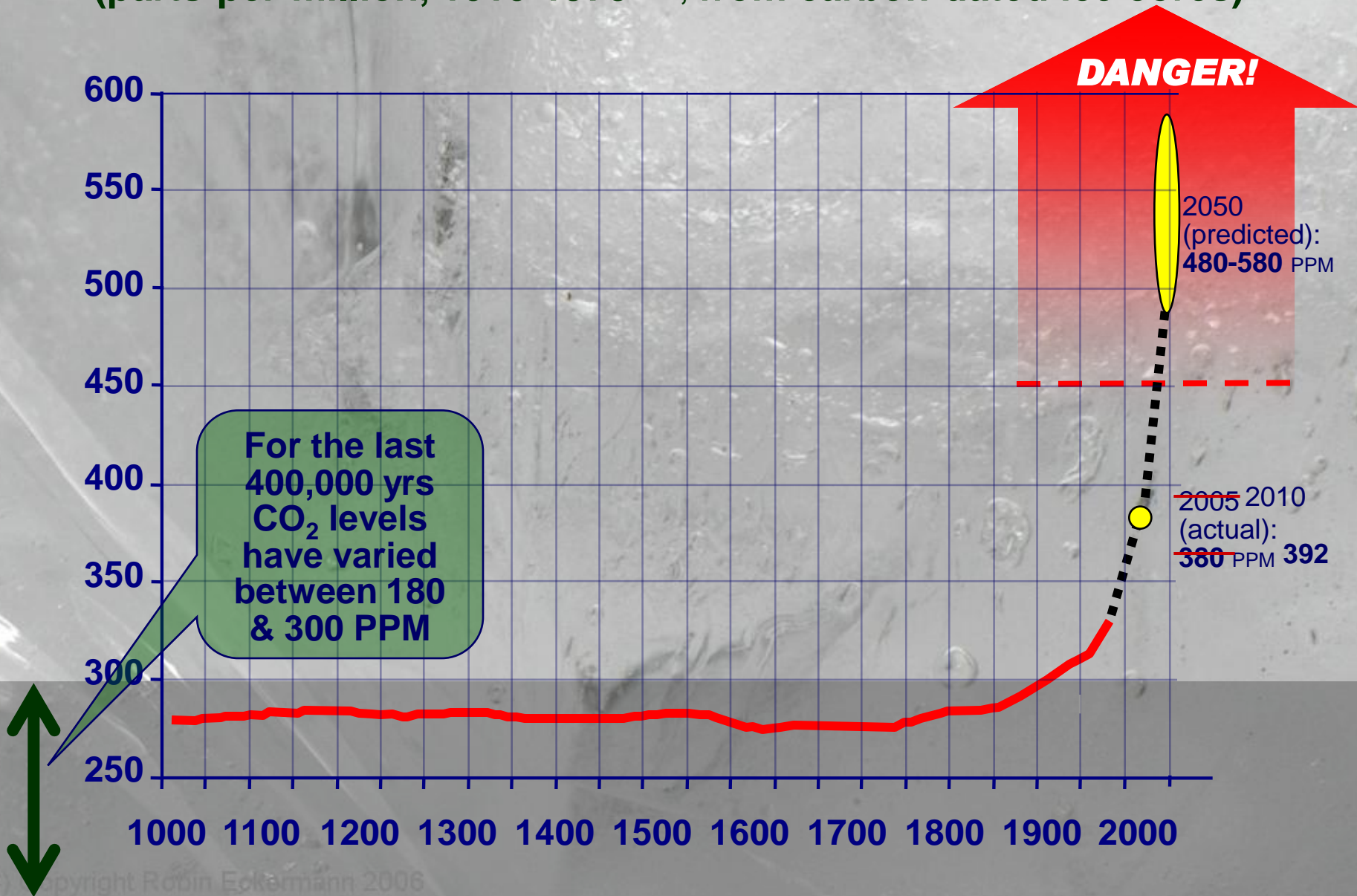
“Blind” Operation

**Largely manual fault
finding & service
restoration**

**Inefficiencies
& losses**

Atmospheric CO₂ Concentrations

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



Electricity is under the spotlight!

Australia 2005:
559m tonnes
CO₂ 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**

An anatomical model of a human brain, showing the cerebral cortex with its characteristic folds and grooves. Several red, branching vessels are visible on the surface. Below the brain, a portion of a human face is visible, featuring a single, prominent blue eye. The background is a plain, light-colored surface.

How can a Grid be made Smart?

By infusing it with:

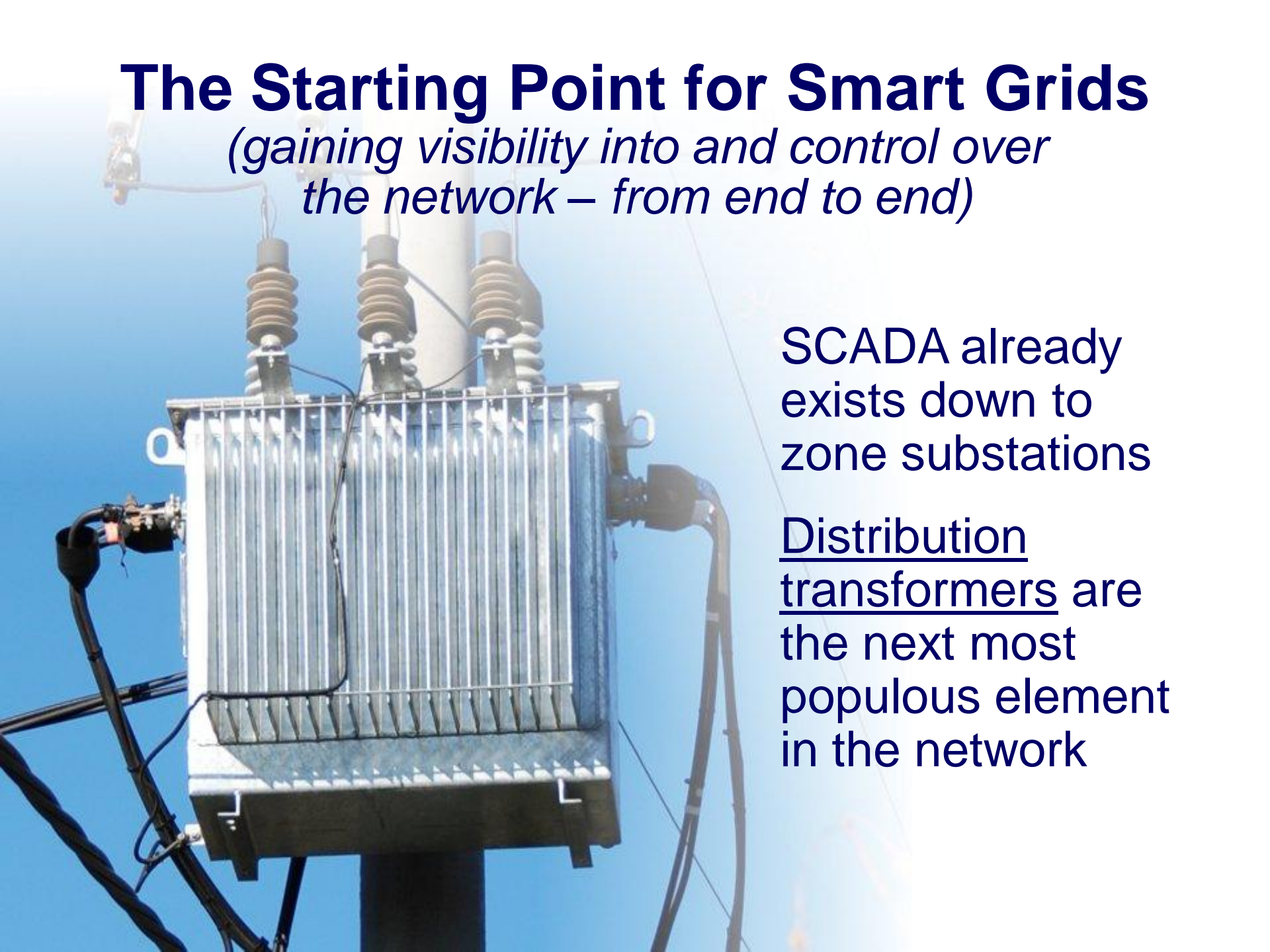
- 1. Sensing**
- 2. Communications**
- 3. Analytics**
- 4. Control**

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



 **current**[®]
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

current[®] Central Systems

currentlook[™]
smart grid services

Transformer

Reports Tools Logout

View



Type: Voltage

Calendar

From: 3/27/2009
To: 3/28/2009

Infrastructure

- 235236791
- 235236827
- 235236875
- 235236890
- 235242980
- 235243520
- 235243598
- 235243619
- 235243634
- 235243772
- 235243825
- 235243861
- 235243882
- 235243942
- 235250157
- 235250304
- 237136800
- 237160766
- 237162437

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- K
- L
- M
- N
- O
- P
- Q
- R
- S
- T
- U
- V
- W
- X
- Y
- Z

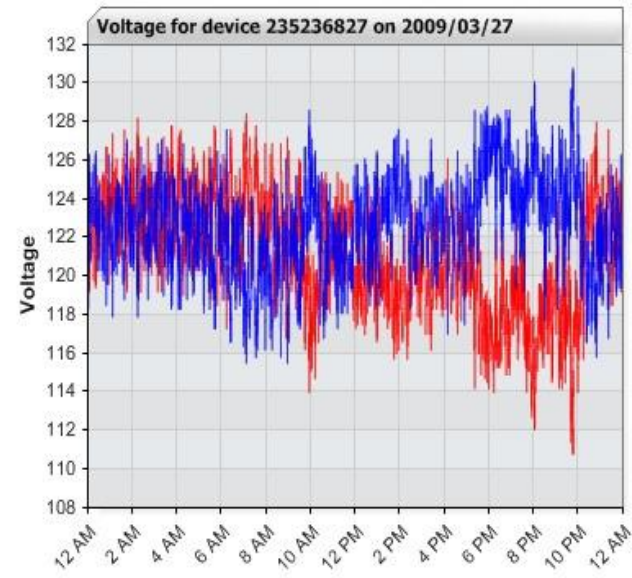
Voltage Usage - SUNS 1413B - Transformer 235236827 Details

Transformer: 235236827 Pole: Company #1: 3 - 0 - 61 - 0 - 82
 Network Element: 09COSUNS018040 FLN: 145 - 216 Company #2: 61 - 82
 Phase / Type / KVA: B / OH / 25 Premises: 9 Company #3:

Date/Time	LV 1	LV 2
2009-03-27 00:00:00	124.400	120.700
2009-03-27 00:00:38	126.300	118.300
2009-03-27 00:00:41	124.599	120.300
2009-03-27 00:02:00		121.599
2009-03-27 00:02:03	123.300	
2009-03-27 00:03:10	121.800	123.300
2009-03-27 00:03:18		124.599
2009-03-27 00:03:29	119.400	126.300
2009-03-27 00:03:40	122.400	122.800
2009-03-27 00:03:43		124.099
2009-03-27 00:03:44	120.700	
2009-03-27 00:04:03		125.400
2009-03-27 00:04:04	119.200	
2009-03-27 00:04:07	120.700	
2009-03-27 00:04:13	122.200	123.500
2009-03-27 00:05:06		122.200
2009-03-27 00:05:40	124.599	120.700
2009-03-27 00:05:42	123.099	122.200
2009-03-27 00:07:37	124.599	120.900
2009-03-27 00:07:46	122.800	122.599
2009-03-27 00:10:02		124.099
2009-03-27 00:10:08		122.800
2009-03-27 00:10:23		124.099
2009-03-27 00:10:24	121.300	
2009-03-27 00:11:33		125.400

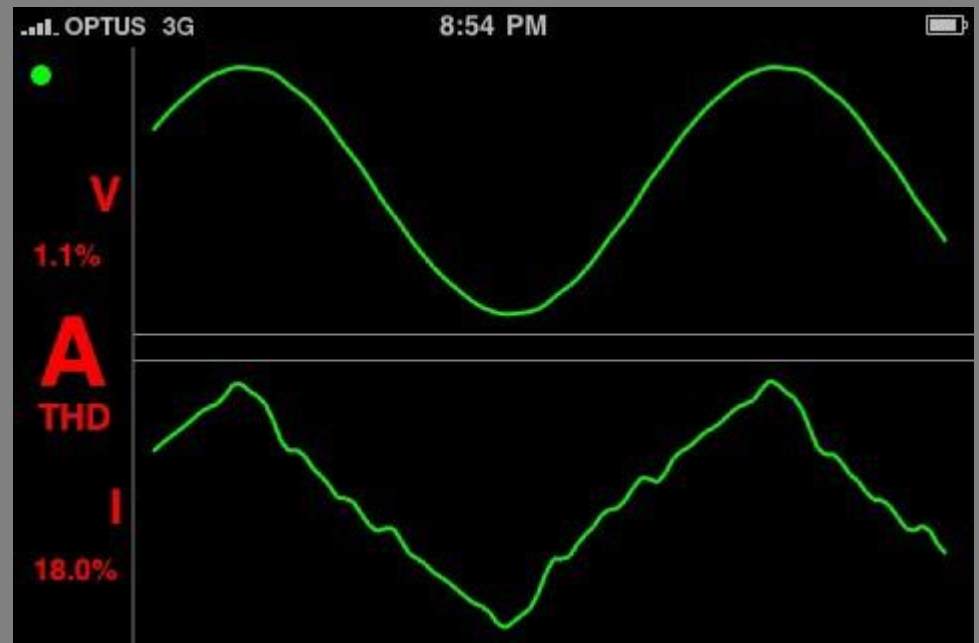
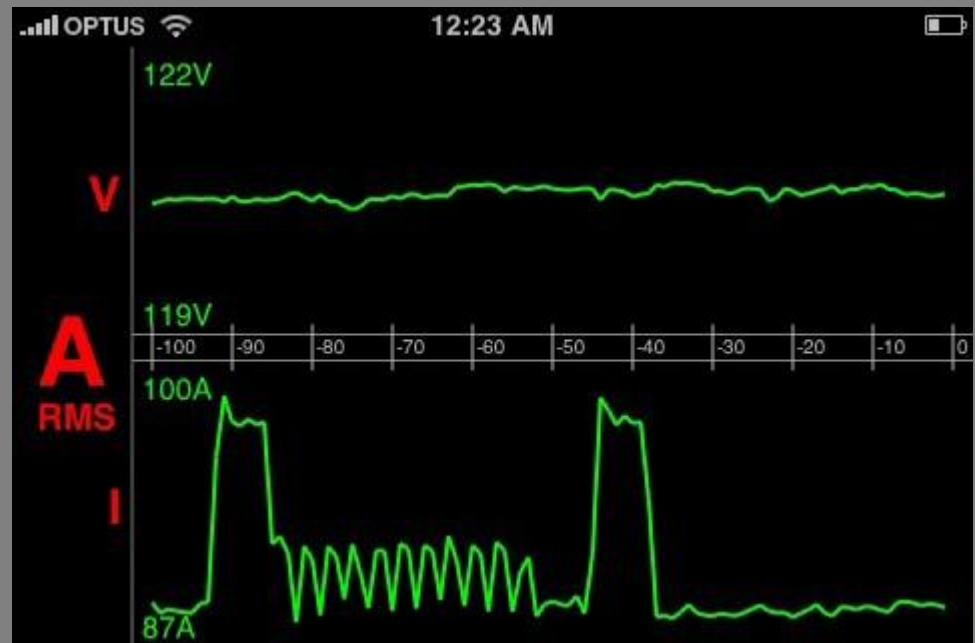
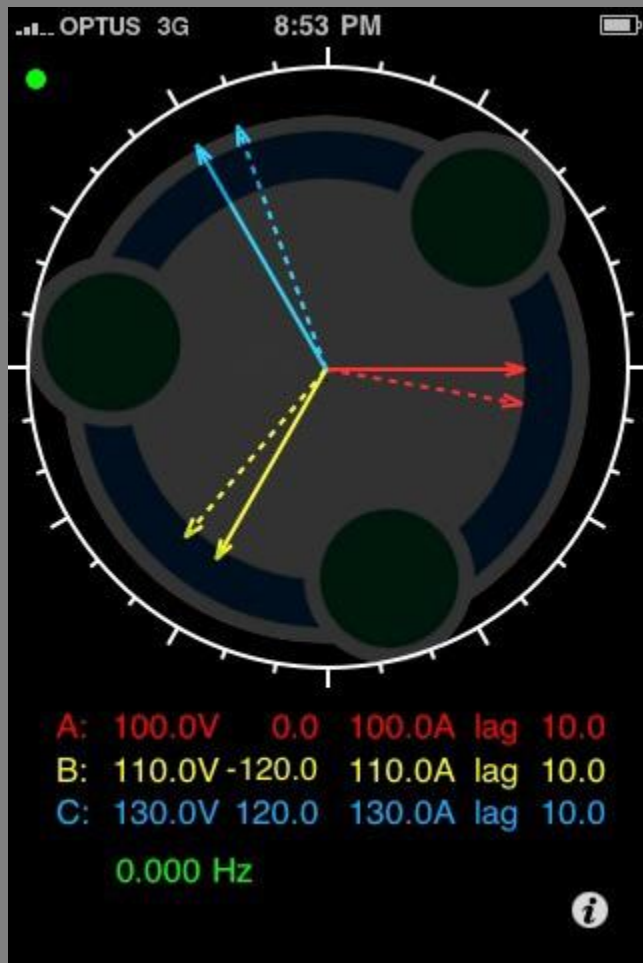
	Mean	Minimum	Maximum
LV 1:	121.226	110.800	128.400
LV 2:	122.714	115.500	130.800

Traces

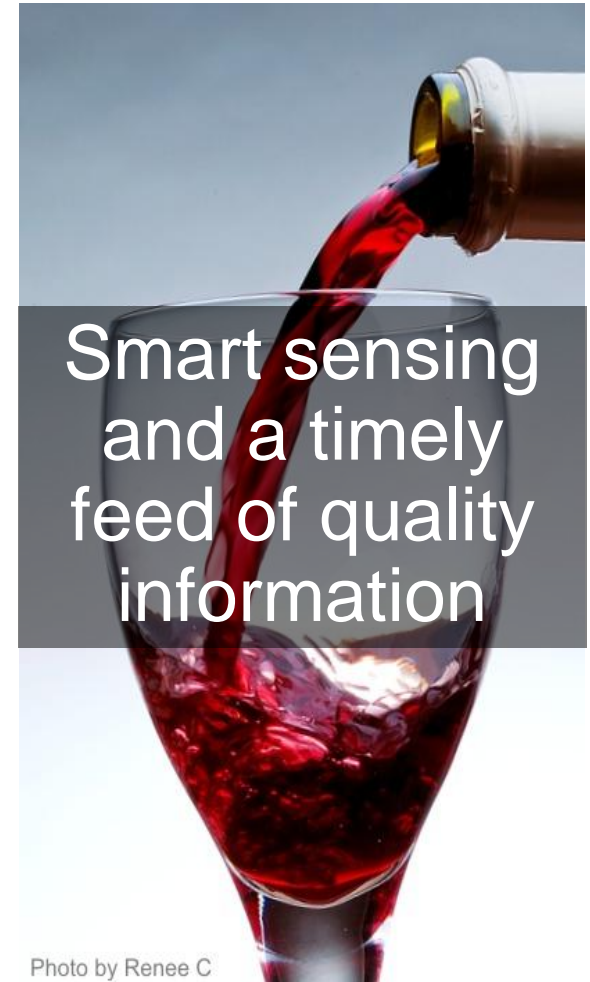
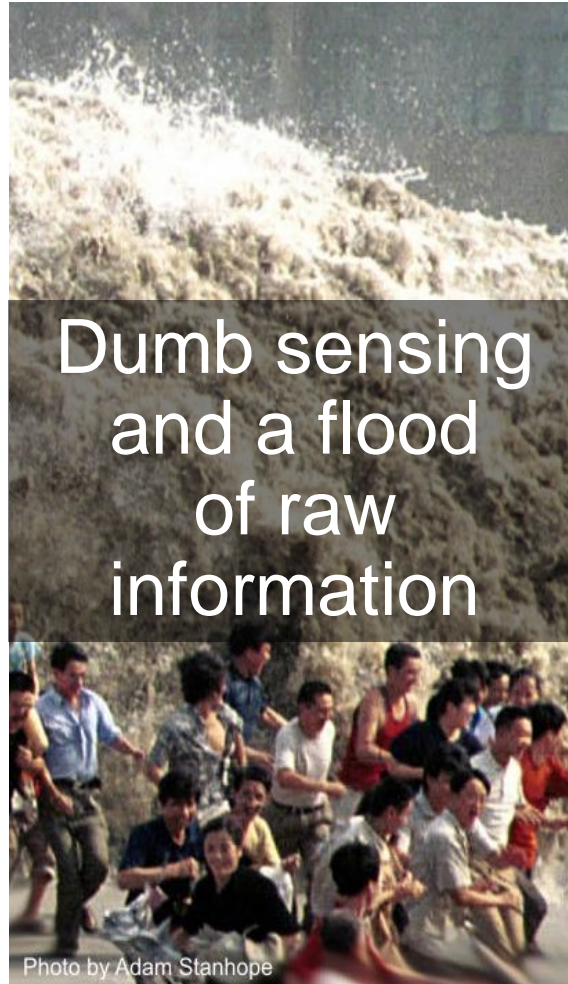
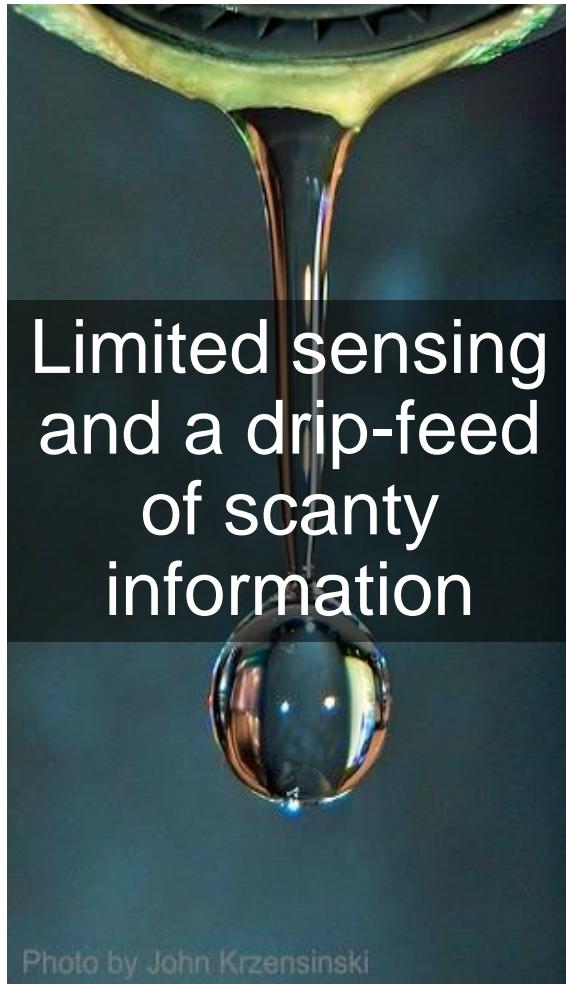


[Export](#)

Portable Monitoring



Communication requirements are influenced by the approach



Critical Requirements for SG Communications Fabric

Reliability
and Security



Low
Latency



Load-handling
Capacity





The Benefits

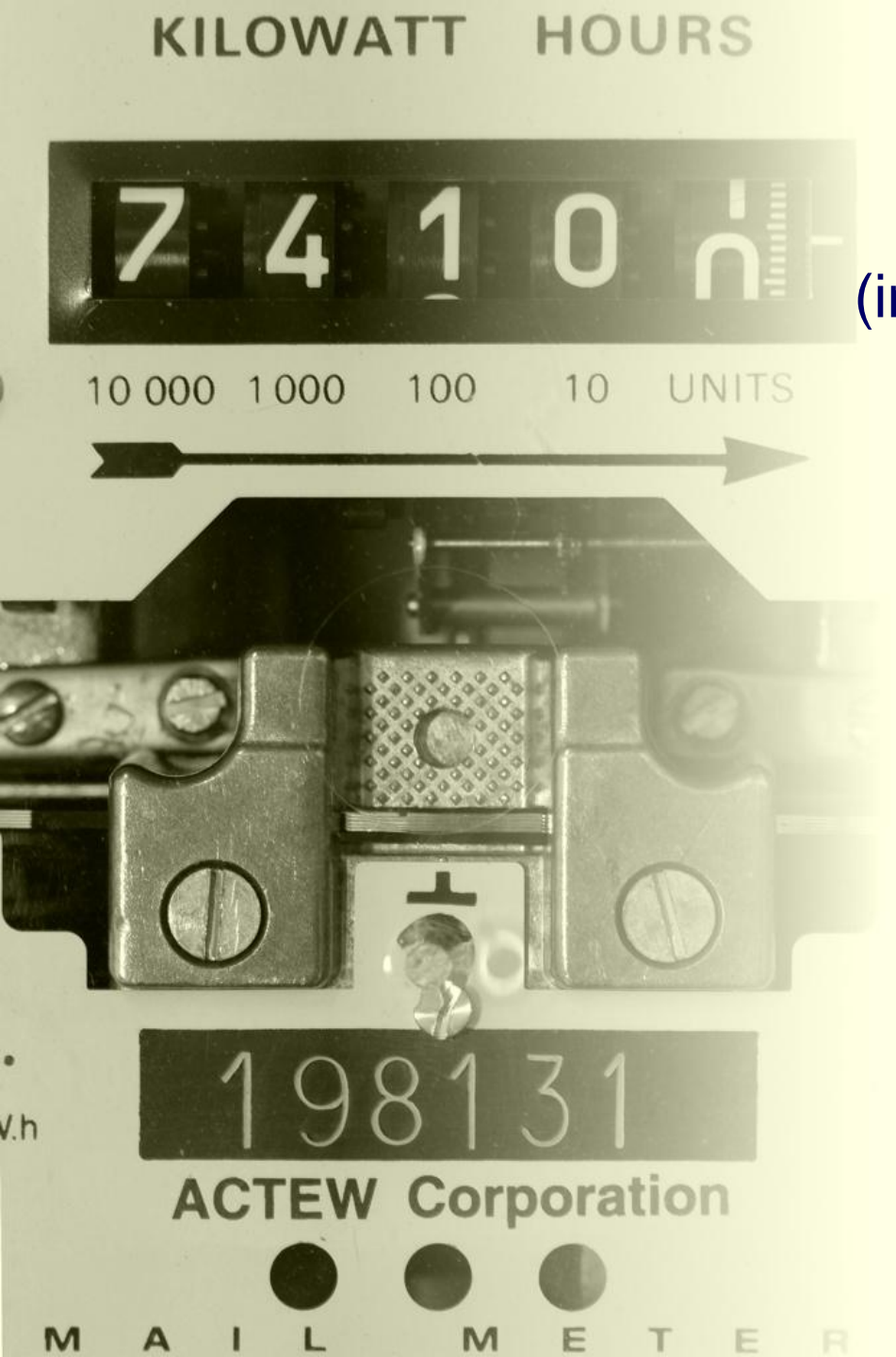
(from the upgrades discussed thus far)

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!

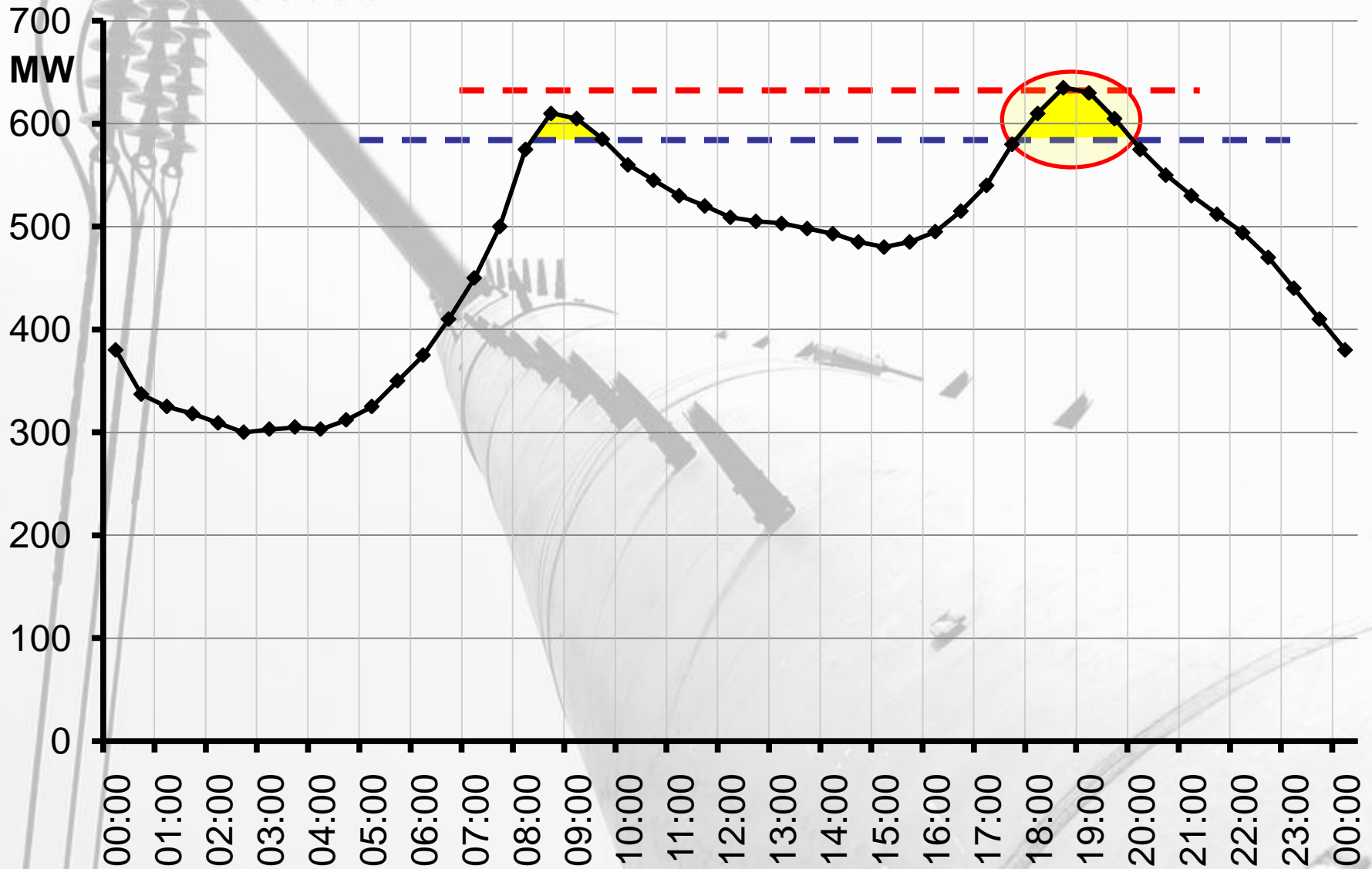
(in extending visibility & control)

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

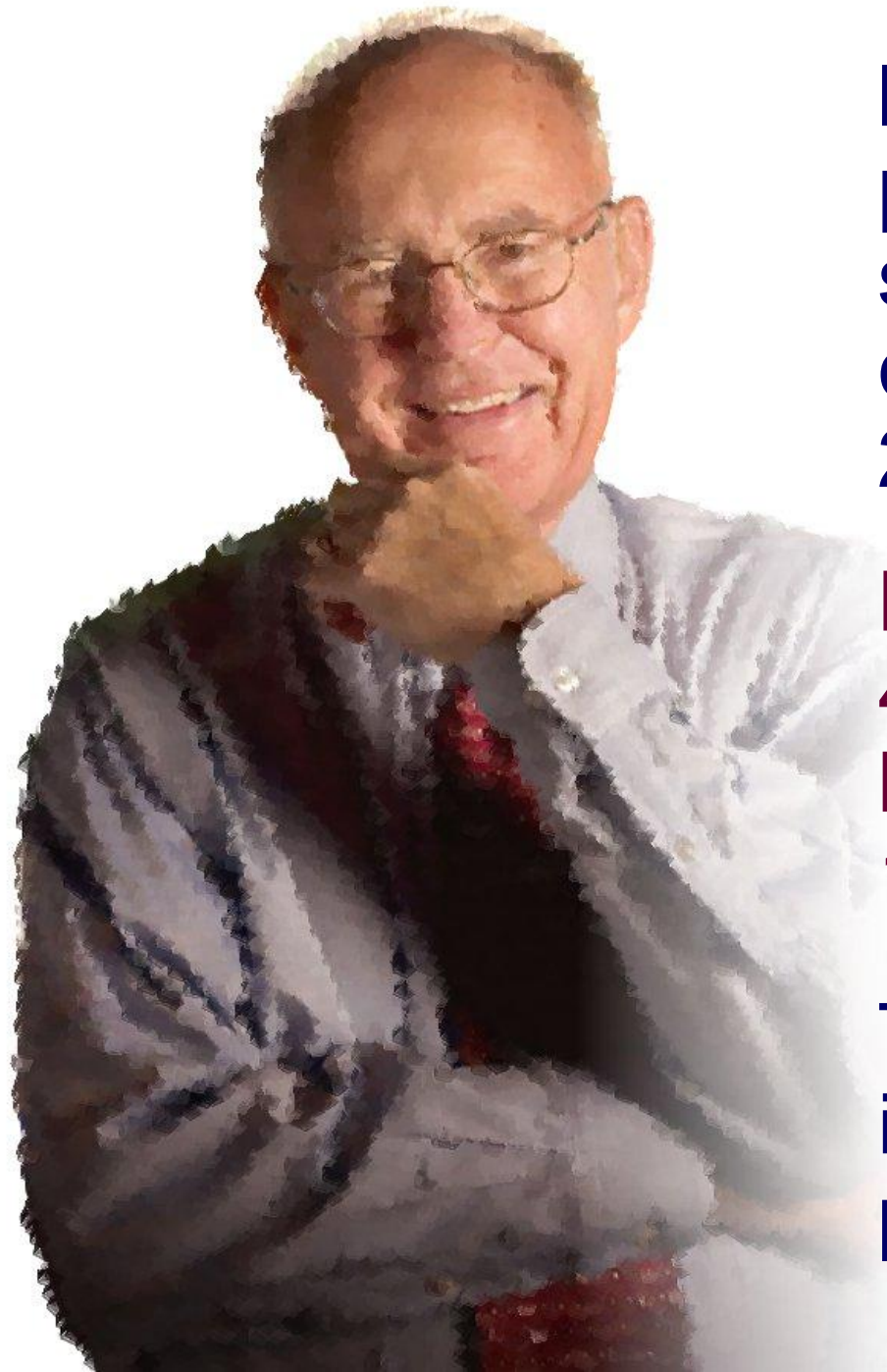


“Smart Meters” (Advanced Metering Infrastructure)



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





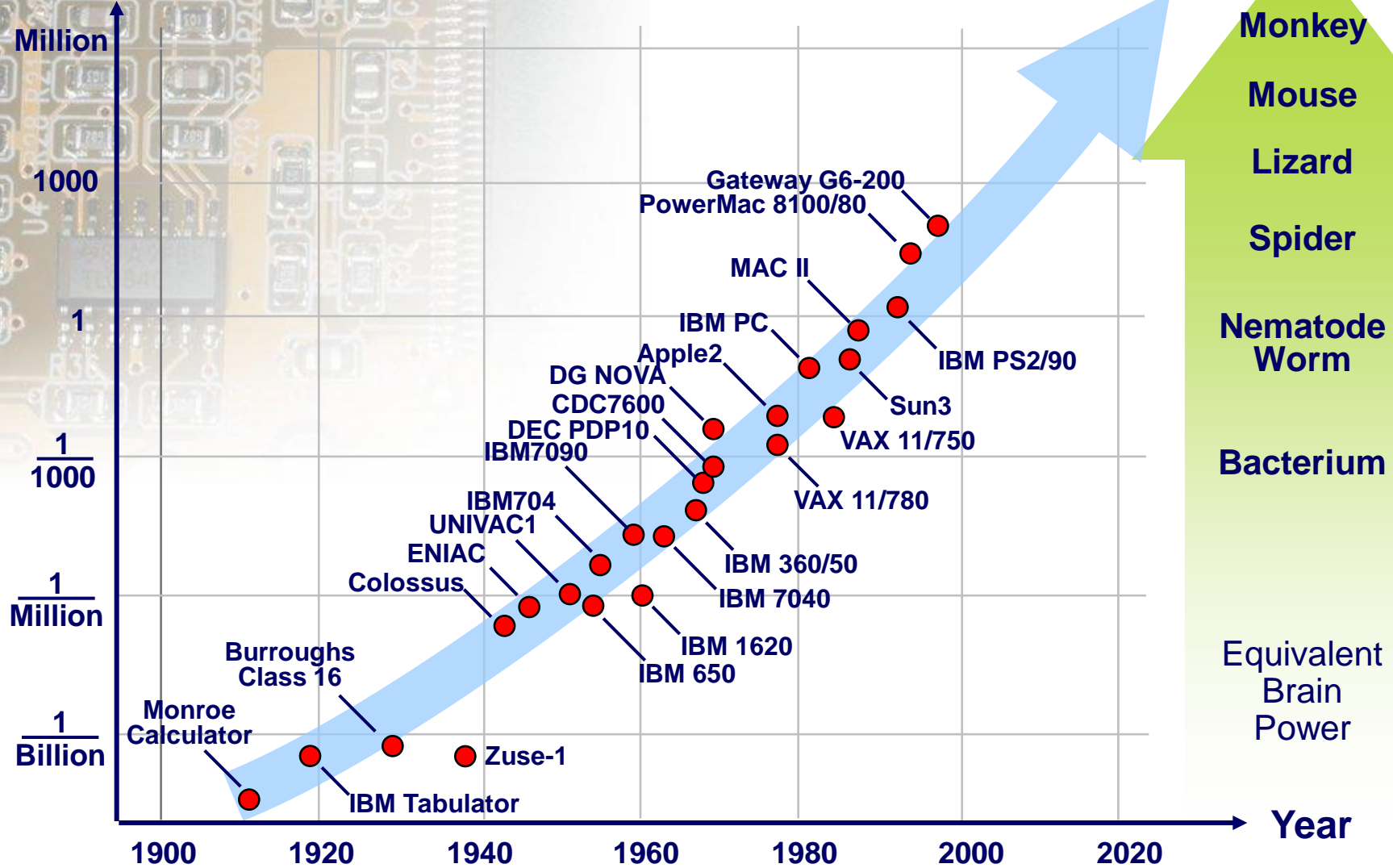
In 1965 Gordon Moore predicted a doubling of silicon densities (and computing power) every 24 months

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!

MIPS (millions of instructions per second) per \$US1,000

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

Renewables

From traditional radial energy flows to a mesh

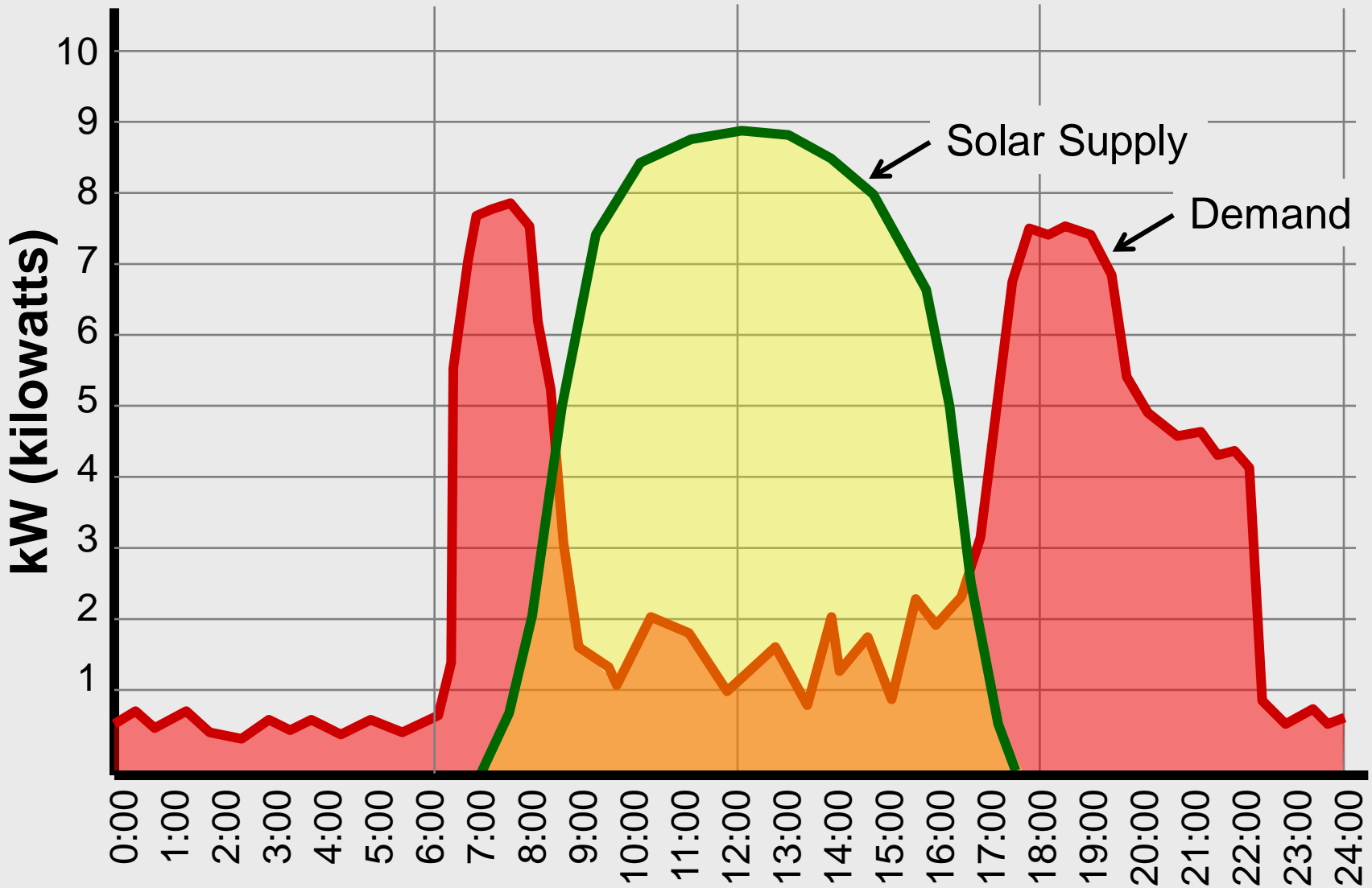
Volatile – either underwrite capacity or dynamically balance supply & demand

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



**Think about the challenges of
high photo-voltaic uptake**

“Hotspots” where supply > demand!





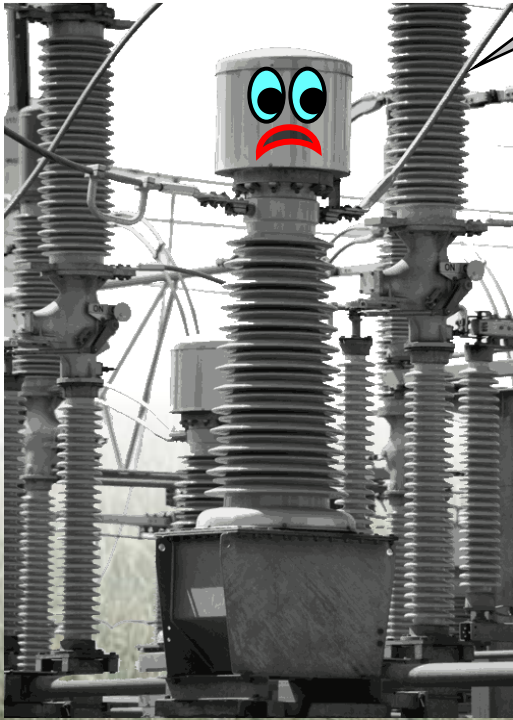
Huge opportunities with emerging appliances like plug-in electric vehicles

Latitude in the timing of overnight recharging

Huge, distributed energy store for the grid

Needs communications!

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!

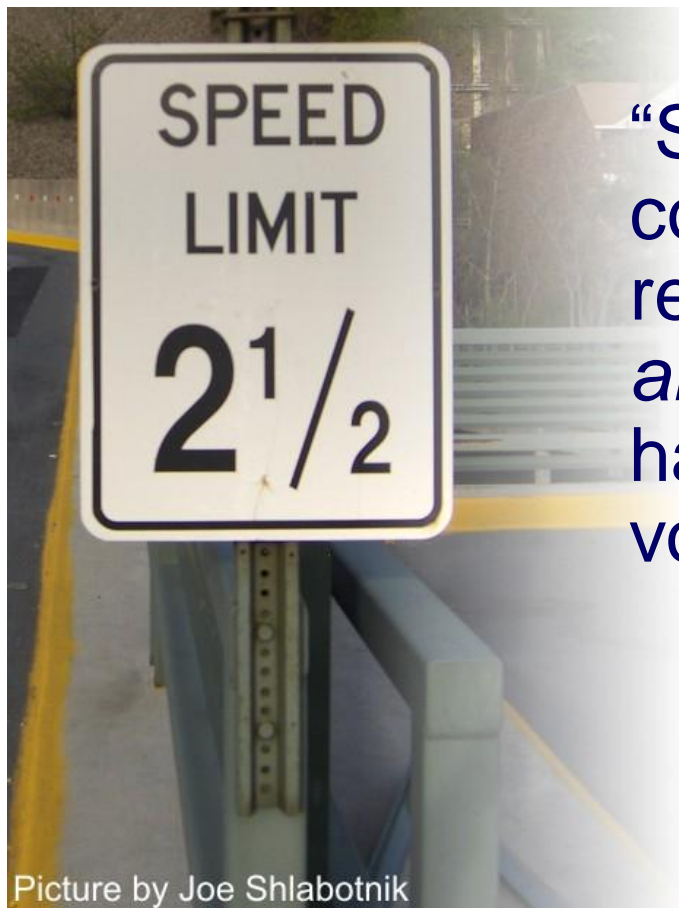
I'm desperate. How about \$1.00/kWh?

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!





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)

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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