

TOSHIBA

Leading Innovation >>>

ICT Research for Energy Management in Smart Grid

Professor Joe McGeehan CBE FREng

3rd June 2010

Overview

- **Toshiba Background**
- **Smart Grid/Smart Metering Background**
 - What are they and why do we need them?
 - Motivations
- **Smart Grids + ICT**
 - Distributed Energy Management Systems
- **Key Research Areas**
- **Summary**

Smart Grid News

Toshiba Wins Order to Supply Okinawa Smart Grid Trial

Jan 2010

- Build Next-gen Electric Power System in Japan (\$55 million)
- Project to use solar panels and rechargeable batteries in Miyako Island.

Toshiba partners with two companies to commercialize smart meters

Jul 2009

- Toshiba smart meter with advanced features in mind, such as data communication & household electrical appliance control functions.

Toshiba (as part of a consortium of Japanese companies) pledges up to \$30m for New Mexico smart grid

Jun 2009

“**Toshiba** aims to expand its energy operations to transmission equipment as countries such as the U.S. and the U.K. invest in upgrades of their electrical systems”.

Toshiba Business Domains

Digital Products

- [Mobile Communications Company](#)
- [Digital Media Network Company](#)
- [Personal Computer & Network Company](#)
- [Toshiba TEC Corporation](#)

Electronics Devices & Components

- [Semiconductor Company](#)
- [Display Devices & Components Control Center](#)
- [Toshiba Mobile Display Co., Ltd.](#)

Social Infrastructure Systems

- [Power Systems Company](#)
- [Transmission Distribution & Industrial Systems Company](#)
- [Social Infrastructure Systems Company](#)
- [Toshiba Solutions Corporation](#)
- [Toshiba Medical Systems Corporation](#)

Home Appliances

- [Toshiba Consumer Electronics Holdings Corporation](#)
- [Automotive Business & Network Services](#)
- [New Lighting Systems](#)

Toshiba – some figures

- **One of the world's largest integrated manufacturers of electrical and electronic equipment**
 - World-wide annual sales of over \$60 billion (USD)
 - Over 200,000 employees
 - Diverse portfolio

- **Annual R&D expenditure of over \$4.2 billion**
 - Fundamental research mated to clear business requirement
 - 15,000 R&D staff in business units
 - 1,750 researchers in corporate R&D centre

Toshiba: History of innovation

東芝

Tanaka Seizo-sho
Hakunetsu-sha

1875

1895 - Japan's first induction motors



1890- Japan's first electric lamps

1900

1915 - Japan's first X-ray & radio tubes



1921- Invented double coil electric bulb
1924 - Japan's first radio receivers



1925

1939 - Became Tokyo-Shibaura Electric Company

1950

1959 - Japan's first nuclear power generator

1970 - World's first video phone

1954 - Japan's first digital computer

1990 - World leading innovations in DRAM

1978 - First Japanese Word Processor

1975

1995 - Development of the DVD



1986 - World's first laptop

1998 - World's first MPEG4 LSI

2000

2005 - Development of the Cell Processor

2004 - World's smallest hard disk

2004 - World's smallest fuel cell

Global R&D

Toshiba Research Europe Ltd

Corporate Research and
Development Centre
Kawasaki



Toshiba America Research
Inc. (TARI)
New Jersey

Research and
Development Centre China
Beijing

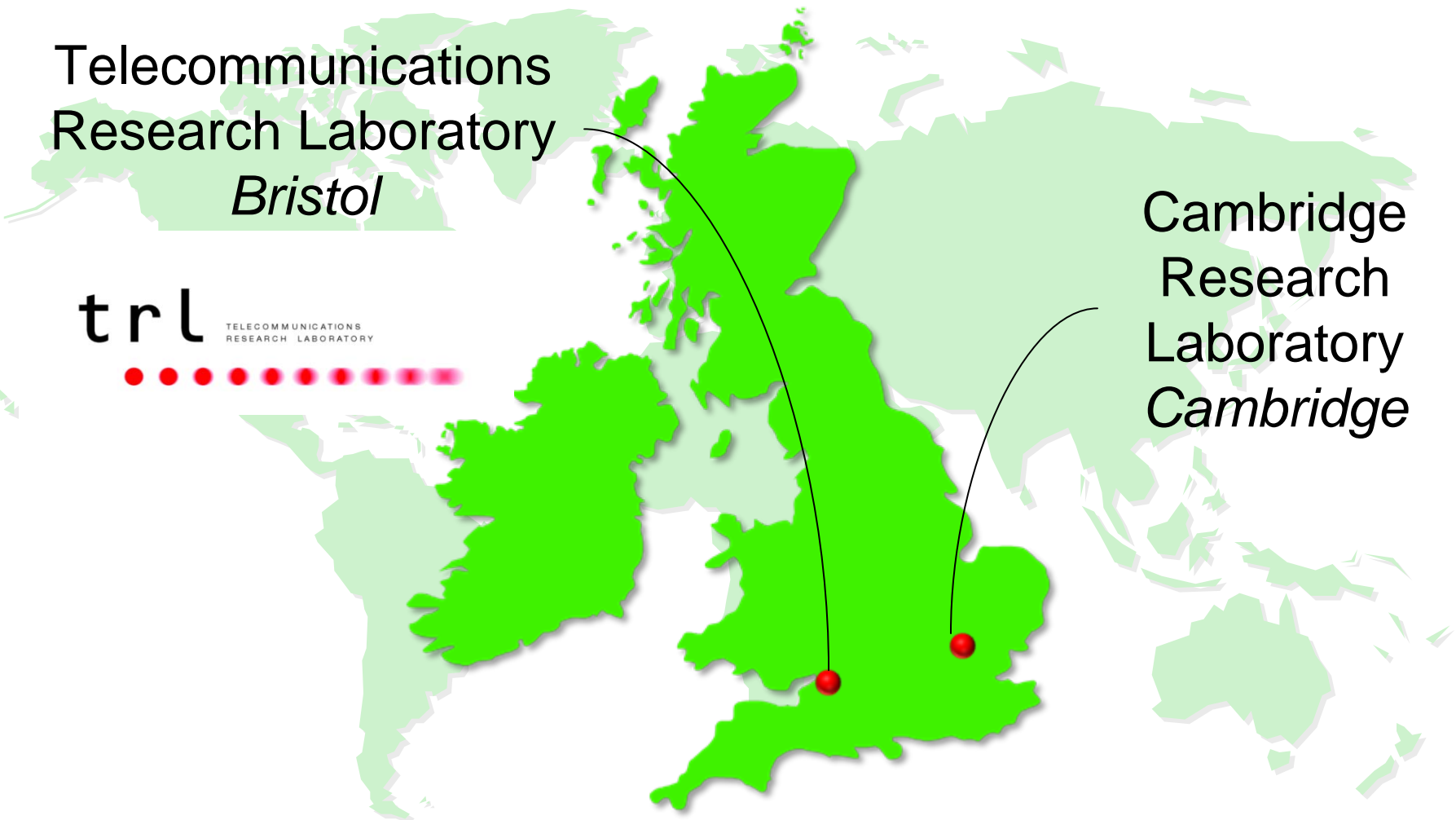
Toshiba Research Europe Ltd (TREL)

Telecommunications
Research Laboratory
Bristol

trl TELECOMMUNICATIONS
RESEARCH LABORATORY



Cambridge
Research
Laboratory
Cambridge



Funded by Toshiba's Corporate R&D Centre, Kawasaki, Japan.

External Collaborations (1)

- **TREL has multiple collaborations with Universities and other technology partners in this area**
 - PhD studentships, MSc projects, collaborative projects, etc.
 - **University of Bristol, University of Cardiff, University of Bath**
 - **CLEVER** - Closing the Loop for Everyone's Energy Resources
 - European projects
 - **3e-Houses** - smart metering/smart home pilot trials (with Bristol City Council)
 - **EPSRC SuperGen II** – in preparation
 - **CONSERN** – Energy Conscious Home Networking
- **We recognise the importance of bringing these 'regional' Universities together to develop novel smart energy solutions together with industry partners**

External Collaborations (2)

- **TREL is part of the South West Microelectronics iNet**
 - An initial £100k of funding has been allocated to help initiate research and development projects in this area of activity
 - Also with a target to foster collaborations and knowledge transfer between universities and industry
 - Especially SMEs, start-ups, etc.
 - Looking to bring together the significant expertise that the area has to offer in electrical and electronic engineering, both from industry and academia
 - **We are involved and are supporting this activity**

Background - Definitions

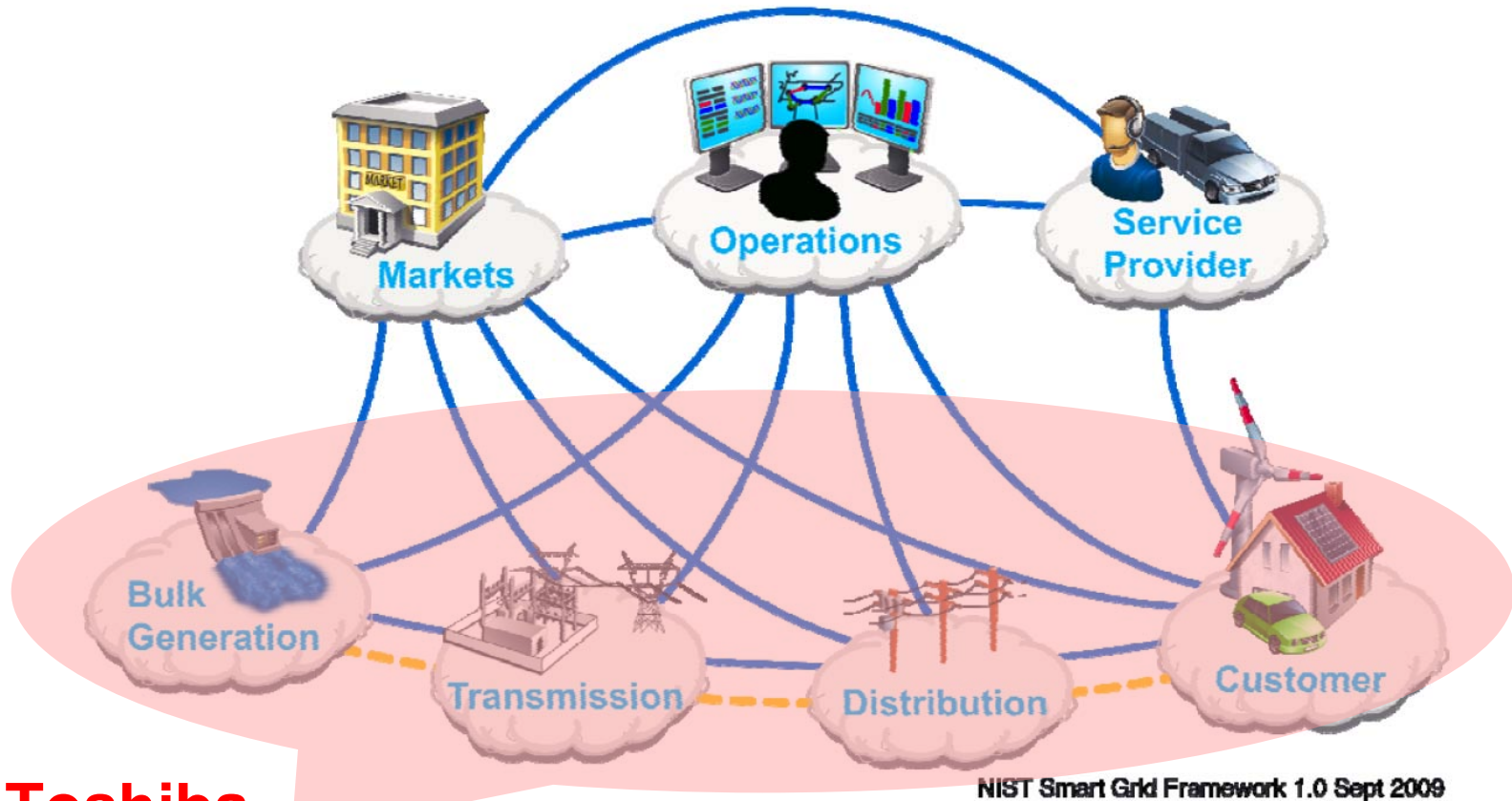
- **Smart Grids**

- An electricity network that can intelligently integrate the actions of all users connected to it
 - e.g. Generators, consumers, and those that do both
- Characterised by the two-way flow of both electrical energy and data associated with it

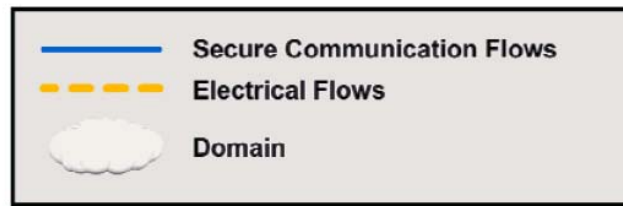
- **Smart Meters**

- An advanced meter that measures energy consumption in much more detail than a conventional meter
 - Usually electrical, but can also integrate or work together with gas, water and heat meters

Background – Conceptual Models



**Toshiba
Expertise**



Smart Grids in Europe - Overview

- **A highly-interconnected, meshed network already exists**
- **Biggest concern is the integration of renewable energy provision to meet the 2020 targets for carbon reduction**
- **A very 'planned' approach to the implementation of smart grid and smart metering technologies in the medium to long term**
- **Current priorities:**
 - Standardisation
 - University research projects
 - Demonstration projects
 - Above projects in cooperation with utilities and manufacturers

Smart Grids in Europe – Key Challenges (1)

- **As laid out in the Strategic Deployment Document for Europe's Electricity Networks of the Future:**
 - **Strengthening the grid**
 - ensuring that there is sufficient transmission capacity to interconnect energy resources, especially renewable resources, across Europe
 - e.g. UK may have up to 32GW of *intermittent* wind power by 2020
 - **Moving offshore**
 - developing the most efficient connections for offshore wind farms and for other marine technologies (the South West is particularly strong here)
 - **Developing decentralized architectures**
 - enabling smaller scale electricity supply systems to operate harmoniously with the total system
 - **Communications**
 - delivering the communications infrastructure to allow potentially millions of parties to operate and trade in the single market
 - Move from 4 meter readings per year to a few *thousand*

Smart Grids in Europe – Key Challenges (2)

- **Active demand side**

- enabling all consumers, with or without their own generation, to play an active role in the operation of the system

- **Integrating intermittent generation**

- finding the best ways of integrating intermittent generation including residential micro-generation

- **Enhanced intelligence** of generation, demand and most notably in the grid

- **Capturing the benefits of DG** (Distributed Generation) and storage

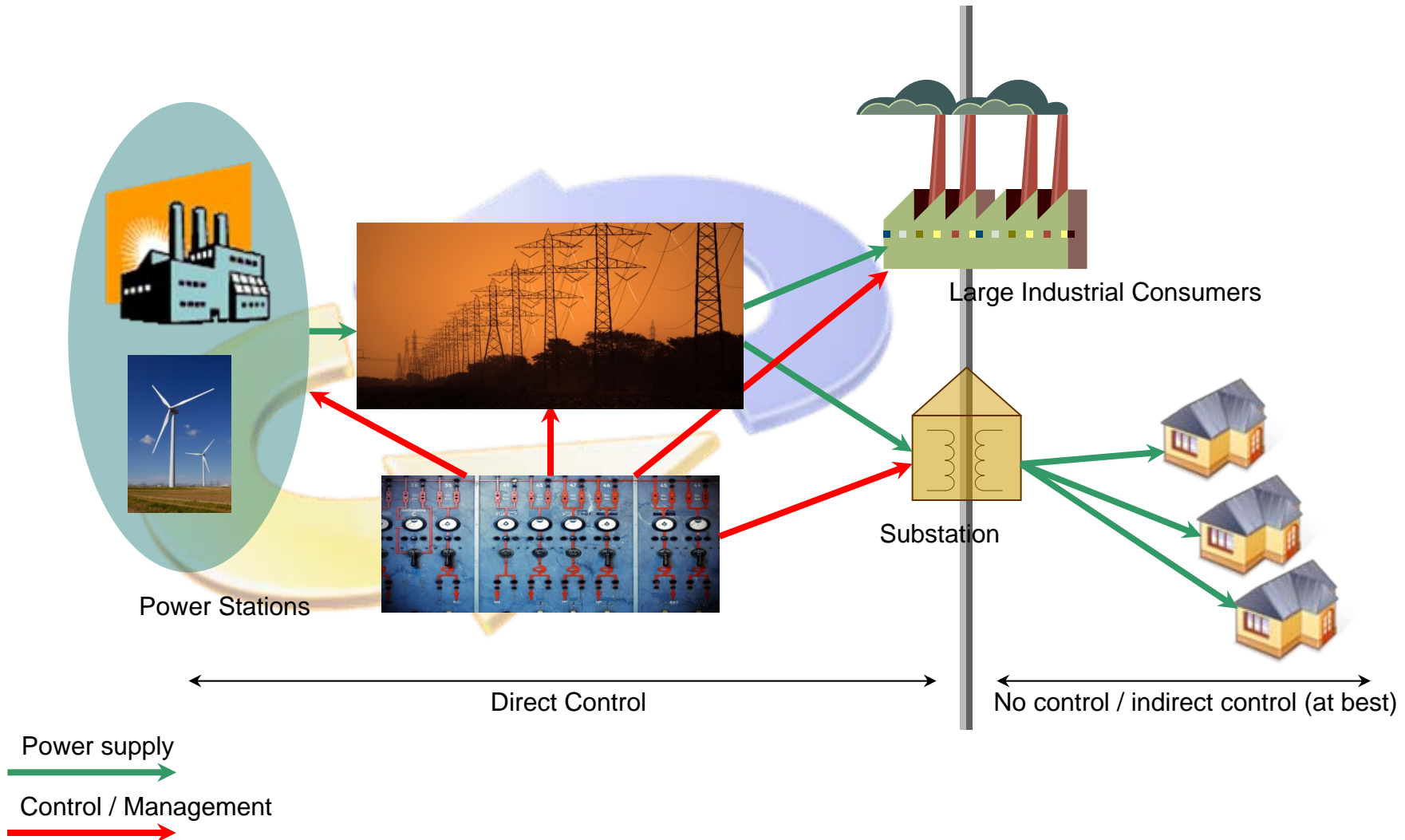
- **Preparing for electric vehicles**

- whereas Smart Grids must accommodate the needs of all consumers, electric vehicles are particularly emphasized due to their mobile and highly dispersed character and possible massive deployment in the next years, what would yield a major challenge for future electricity networks.

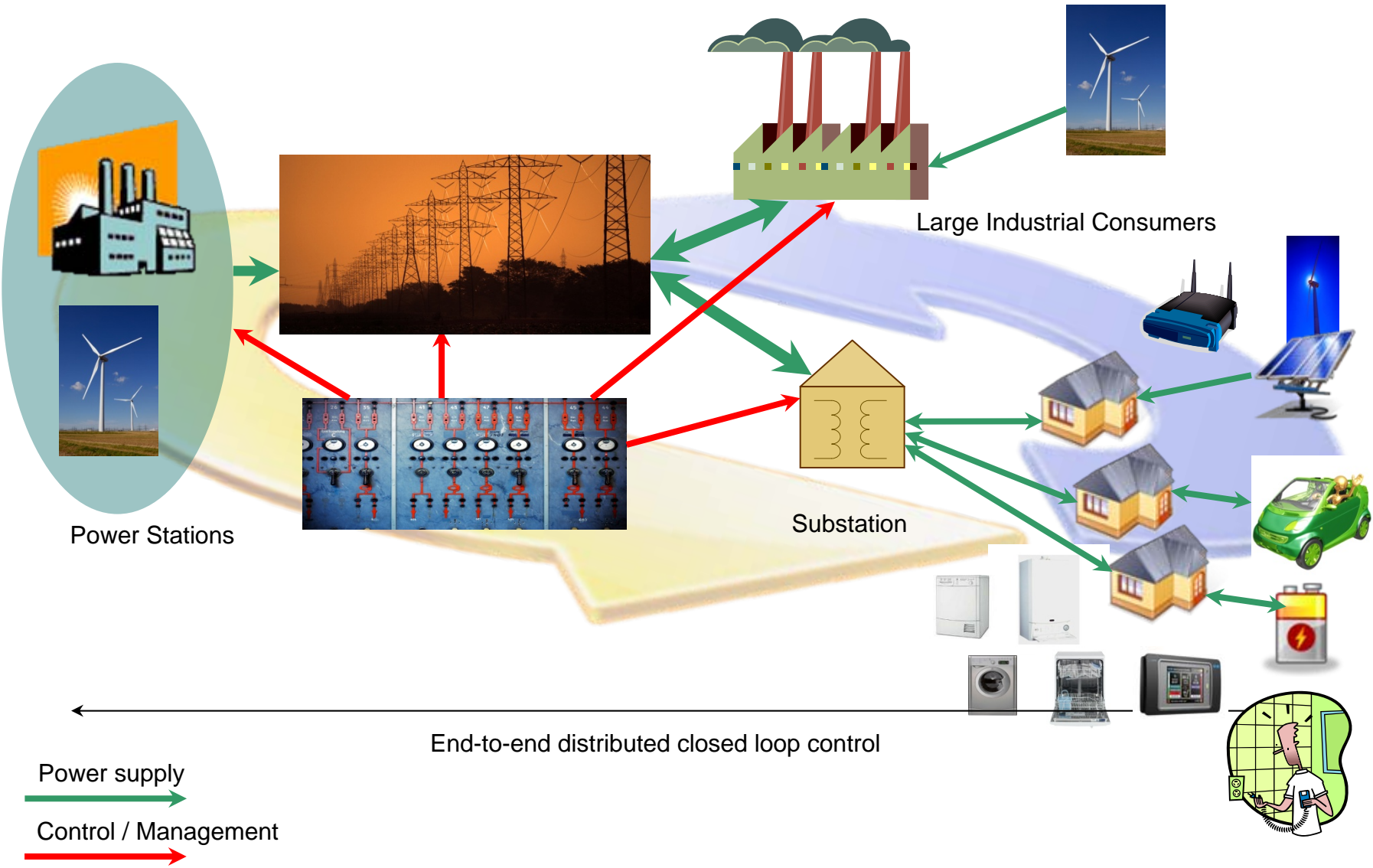
Energy management is a need

- **Demand from all sides for sustainable solutions to address energy usage:**
 - Customers, Regulatory / Government, and Business
 - Due to dwindling resources, highly volatile and increasing prices, climate change and GHG emission controls, aging and insecure infrastructure
 - *“...the UK’s peak electricity demand could exceed available capacity by as early as **2017**, due to the planned closure of nuclear and coal power stations – and a potential short-term gap in replacement power generation solutions.”¹*
- **Efficient energy usage is a major societal issue and an essential need.**
 - However, *the business case is yet to be made!*
- **Technical arguments and solutions are known – in separate, distinct domains.**
 - *How to make them work on a large scale is unknown.*

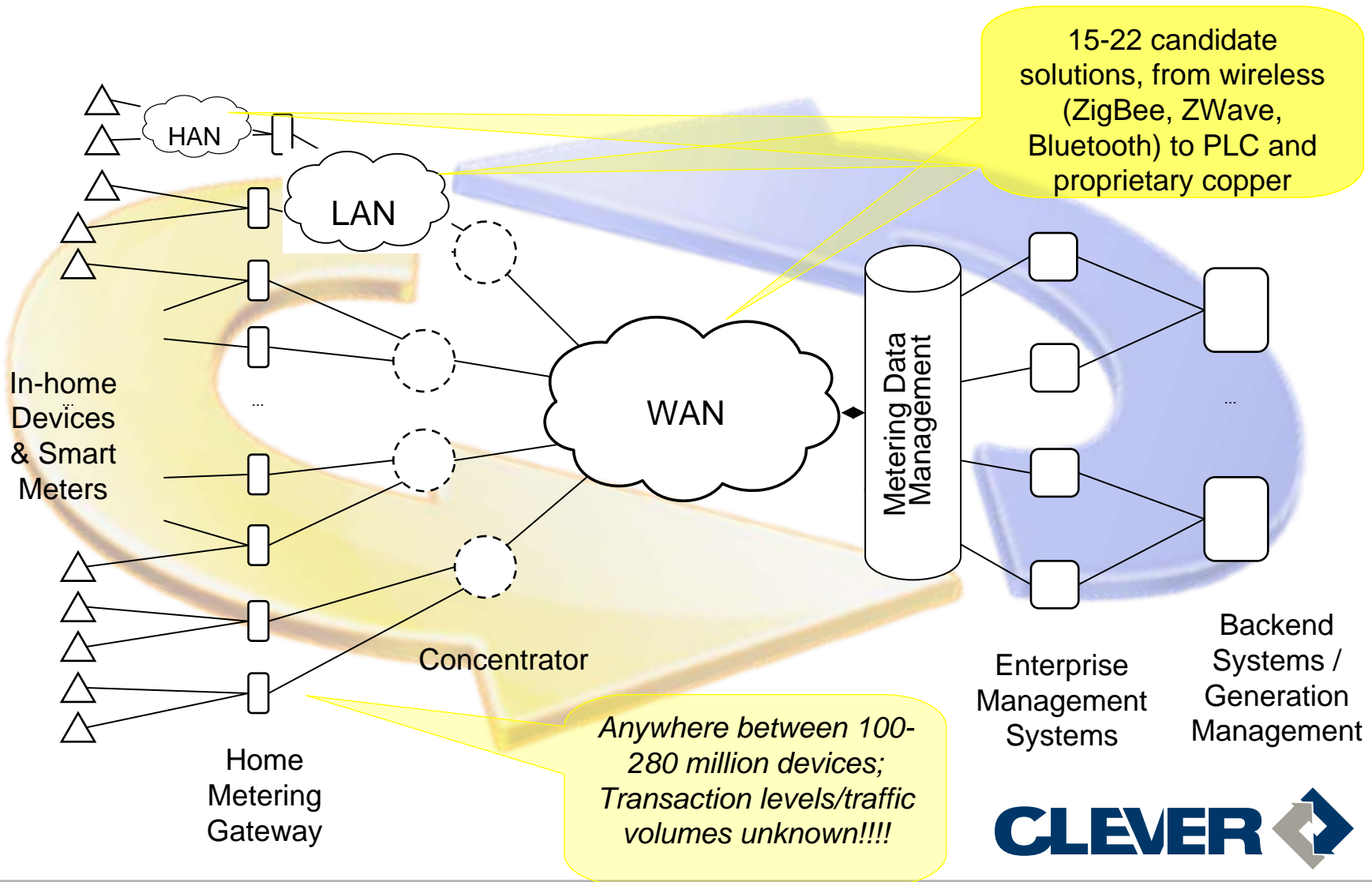
From grids today



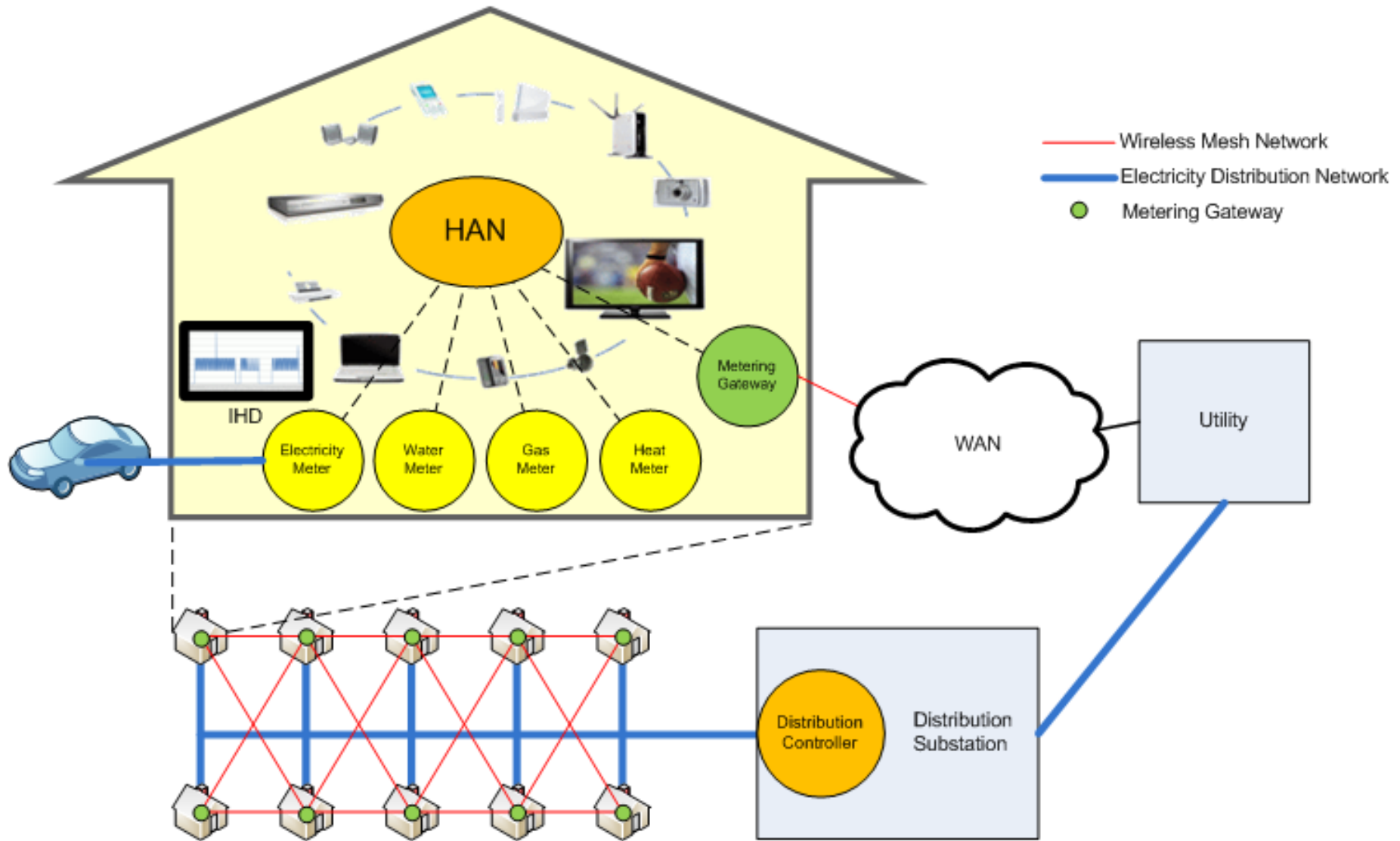
... to Smart Grids



Closing the loop for energy management



Example Home Smart Metering Architecture



Toshiba SCiB



Long life

More than 6000 charge-discharge cycles.

Safety

Safe from rupture and ignition even under severe conditions.

Rapid charging

Rechargeable in as fast as 5 minutes.

High power

High power density even equal to that of a capacitor.

Large usable capacity

A wide usable SOC range assures large usable capacity.

Cryogenic performance

Functions at cold temperature as low as -30°C

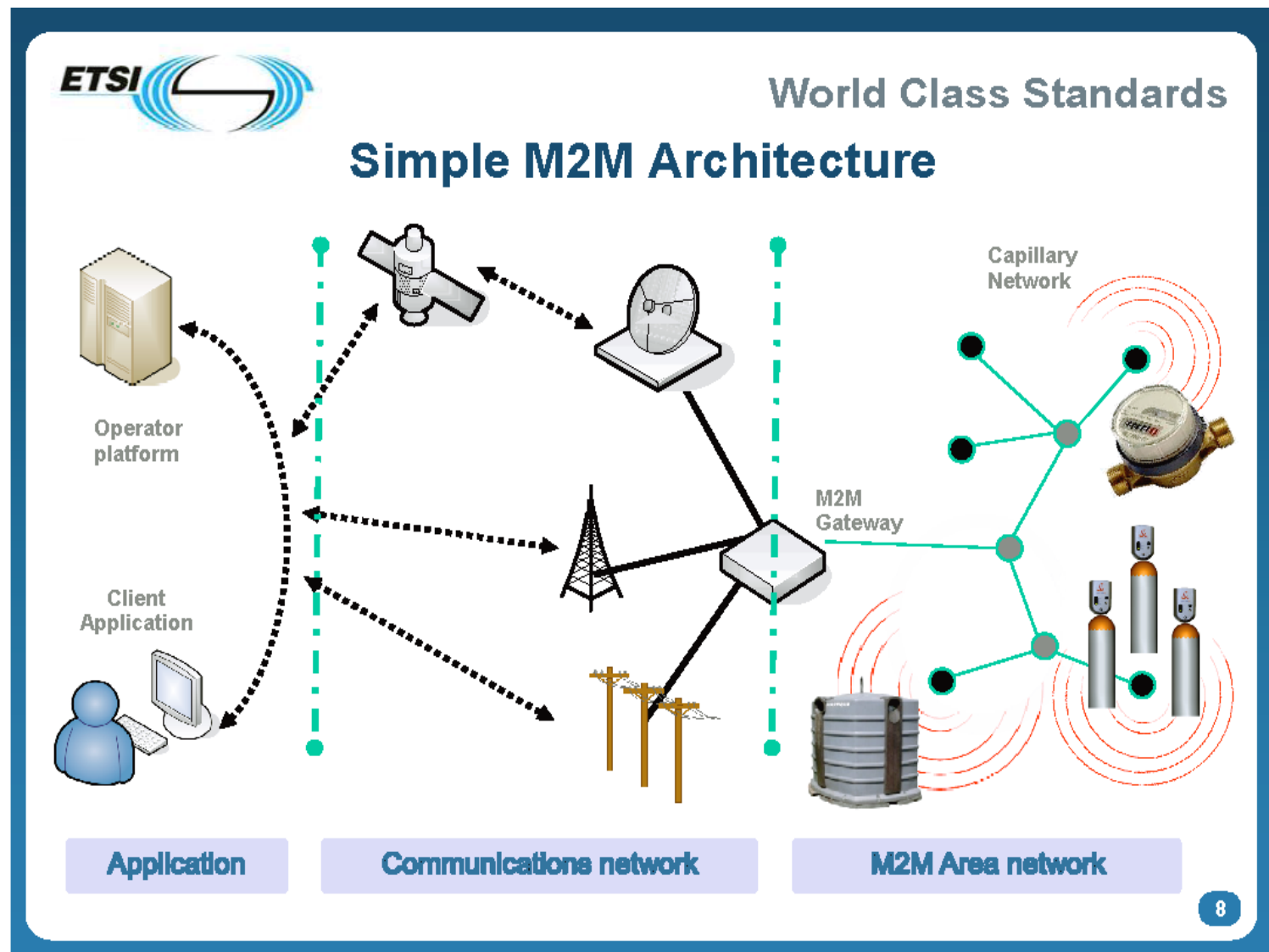
Smart Grids as large scale ICT systems

- Communications, information flows, security, complexity ...THE REALITY
- Just in the LV part of the UK grid we can have 200-300 million devices (meters, controllers, appliances, gateways, etc.)
- In different hierarchical control structures, but all connected together
- Using various connectivity solutions (from short-range to Femto-Cell to distributed PLC to WAN solutions)
- Over the same networking protocol ? (IP)
- Just for smart metering the calculated volumes for meter reading transactions are 8736 times higher than now, if 15 minute intervals are used
 - Add on this more frequent tariff changes; what about demand control/demand response algorithms?

Distributed Energy Management Systems: SmartGrids + ICT

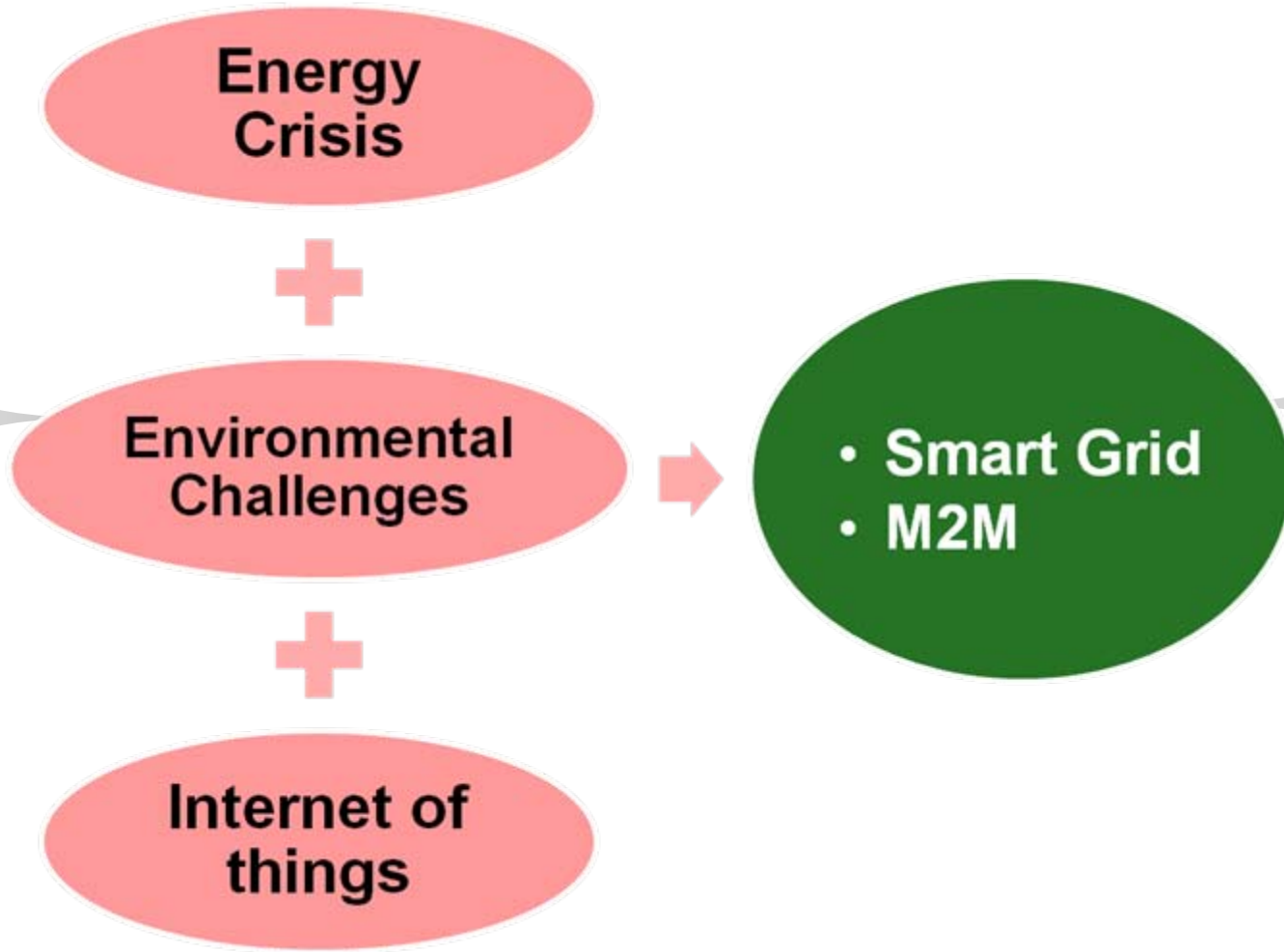
- **Large number of algorithms for demand management/response exist**
- **The first time that these algorithms can be run end-to-end, linking energy generation, distribution, retail and consumption**
- **What would the users do?**
 - Privacy, security and fair access to data are big issues for acceptance
 - User behaviour modelling - large population, distinct groups converging in subset of behaviours.
- **Energy SLAs – the business case to drive communication SLAs and the whole system**
- **Requires new understanding of the interplay between DEM systems, grid control components and end users**

Standardisation – ETSI M2M Architecture



Challenges and Opportunities

Social, Political, Economic, Environmental & Technical Issues
That Affect Us All



Business and Research Opportunities for
Energy and ICT sector

Key Research Areas

- **Load balancing/shedding/peak management on a highly distributed scale**
 - Can we produce algorithms that reduce peak energy demand, whilst still satisfying consumer requirements?
 - e.g. electric vehicle charging times
- **Large-scale integration of renewable energy sources**
 - Main problem is the intermittency of supply – wind turbine power output is related to the cube of wind speed!
- **Communications in a sensor network with $> 10^8$ nodes**
 - How much data will be needed? Where does it need to go? **Can we handle it?**
- **Security and Privacy**
 - What is happening to all of my smart metering data? Who can see it? What information about me can be extracted from it? **How can we protect privacy?**

Summary

- **Toshiba has a long history of diversity and infrastructure provision**
- **Toshiba has expertise across the board of smart grids and smart metering**
 - Toshiba is one of perhaps only a small handful of companies that encompasses so many diverse technologies that will be related through Smart Grid initiatives
- **Important areas and activity**
 - APIs/Interfaces for interoperability and security, system modelling and performance analysis
- **Smart grid challenges across Europe**
 - Millions of meter readings every day!
- **Standards – Toshiba has expertise and interest in all of the areas covered by the EU M/441 mandate**

Standardisation – Mandate M/441 EN

- **Issued by the European Commission in March 2009**
 - *“...to create European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which customers’ awareness of actual consumption can be raised in order to allow timely adaptation to their demands (commonly referred to as ‘smart metering’).”*
- **Timescales:**
 - European standard for communication by March 2010
 - Harmonised solution for ‘Additional Functionalities’ by December 2011
 - Combined progress report from relevant ESOs (European Standardisation Bodies) by October 2010

TOSHIBA

Leading Innovation >>>