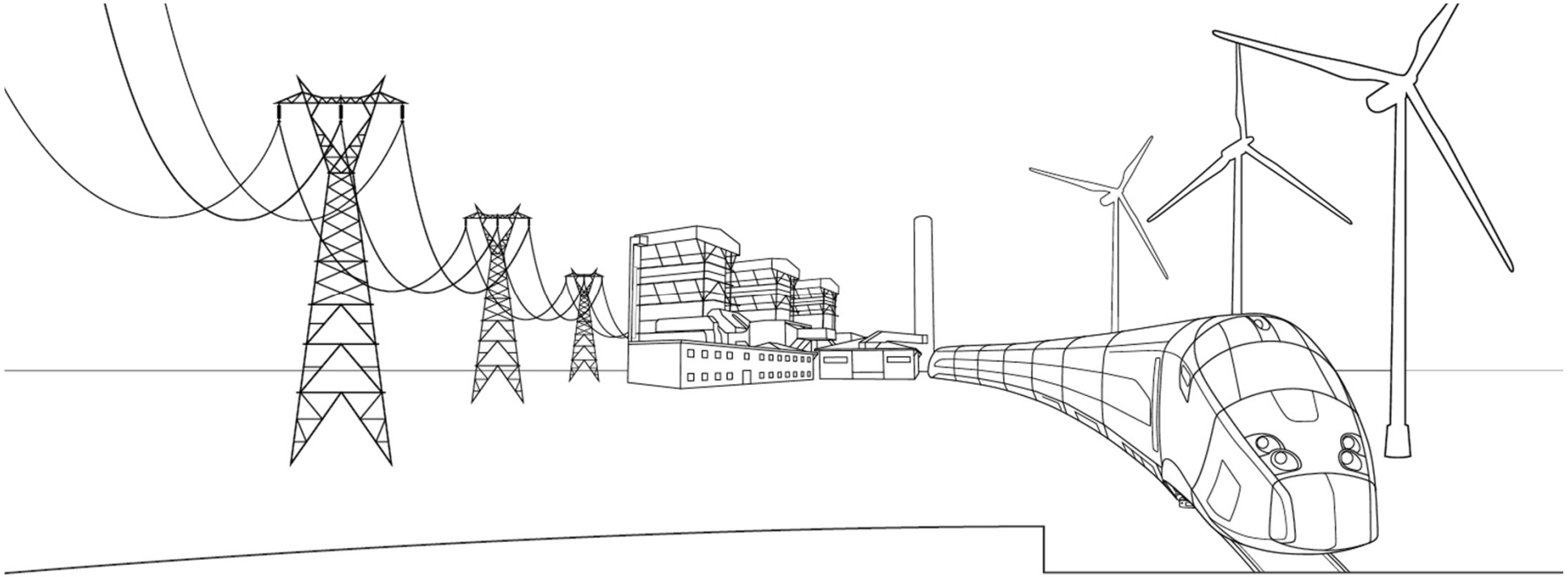


Ronan STEPHAN

Systemic challenges that smart territories will face

Tuesday, January 15th 2014

OIST OKINAWA INSTITUTE OF SCIENCE AND TECHNOLOGY GRADUATE UNIVERSITY
沖縄科学技術大学院大学

The First International Symposium on Open Energy Systems

ALSTOM
Shaping the future

Agenda

Context and Forthcoming Trends… What if?

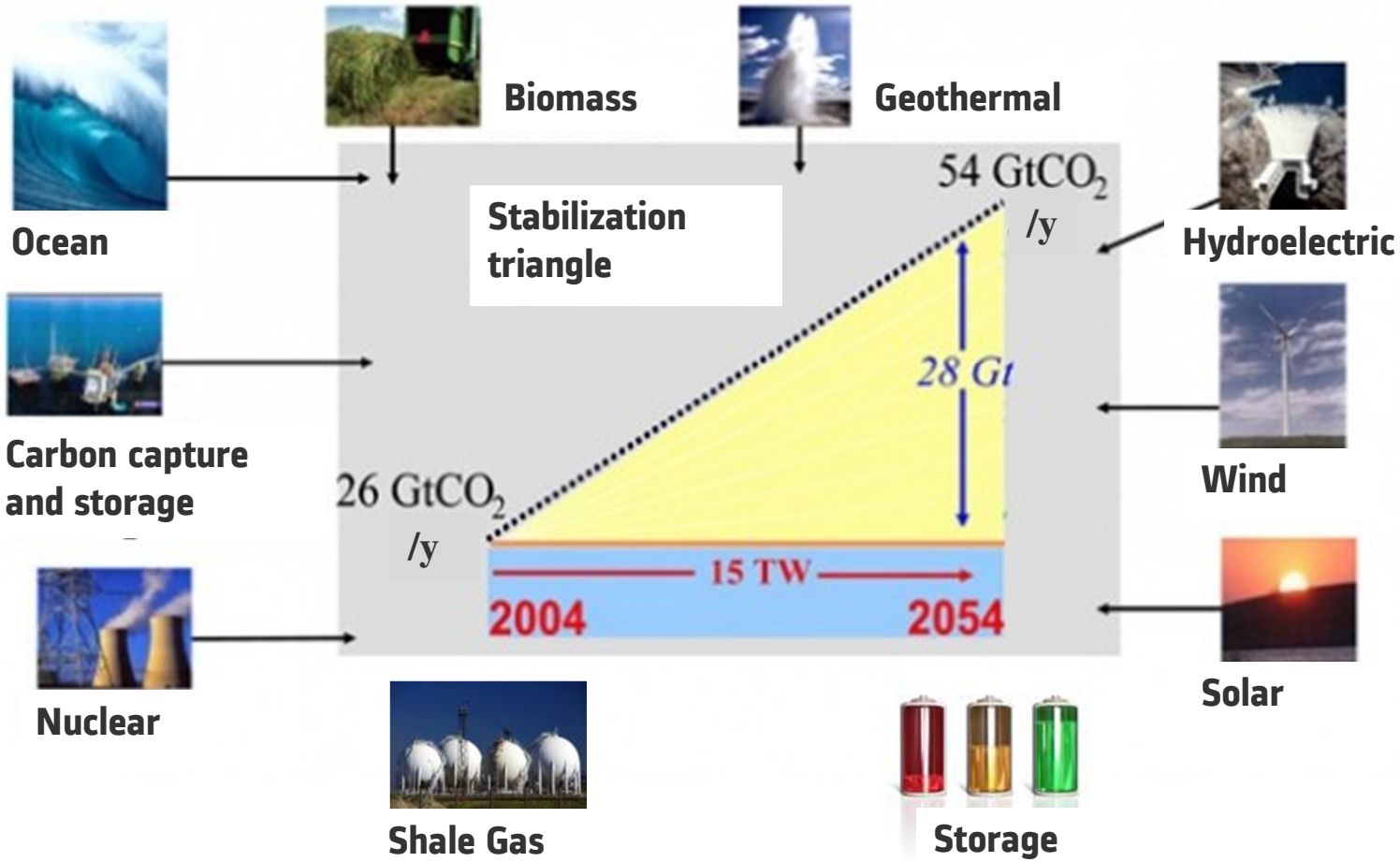
How to adapt?

Which challenges?

Which “enablers”?

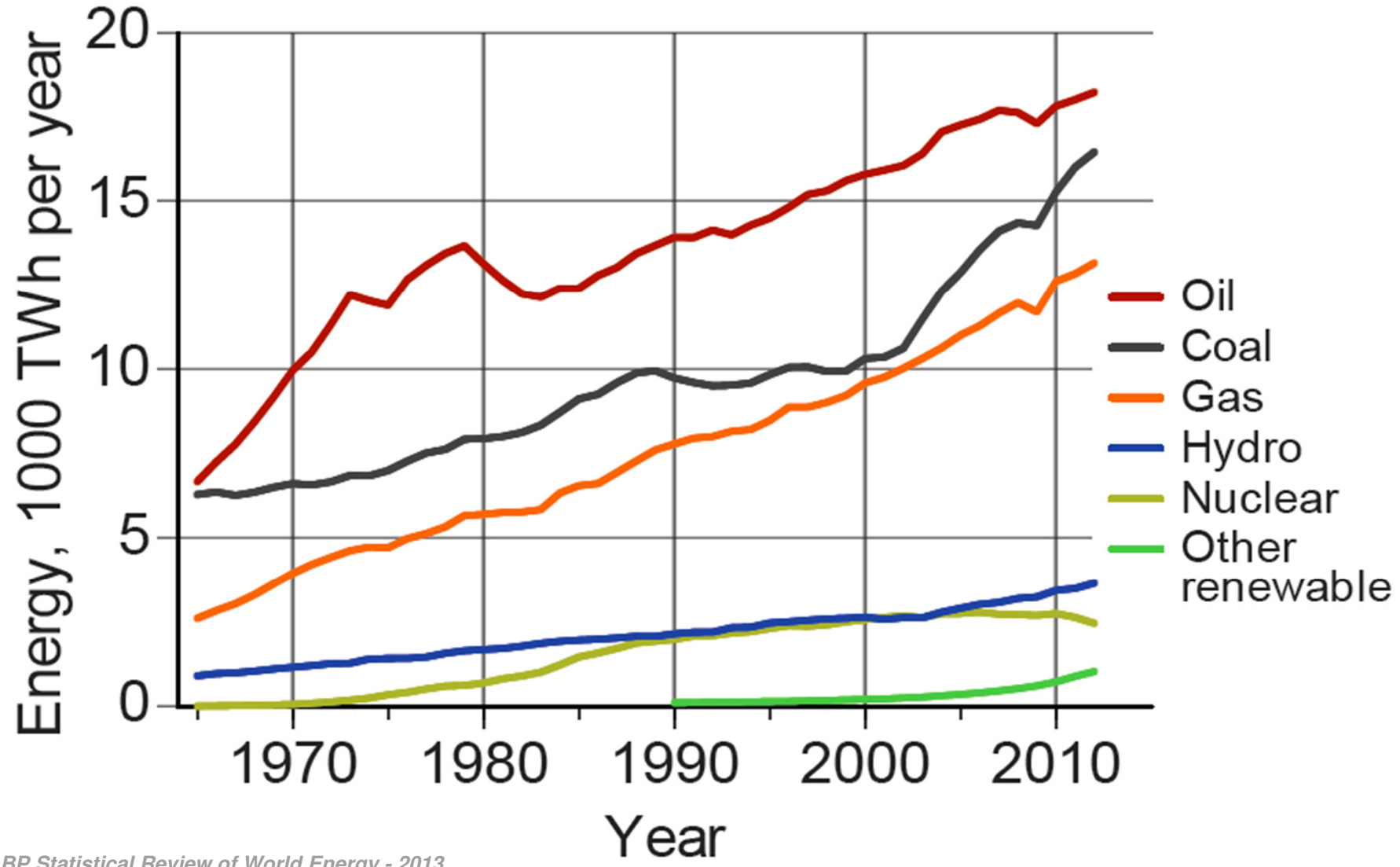
ALSTOM

As a preamble…
Energy mix, limitations and mitigation challenges



ALSTOM

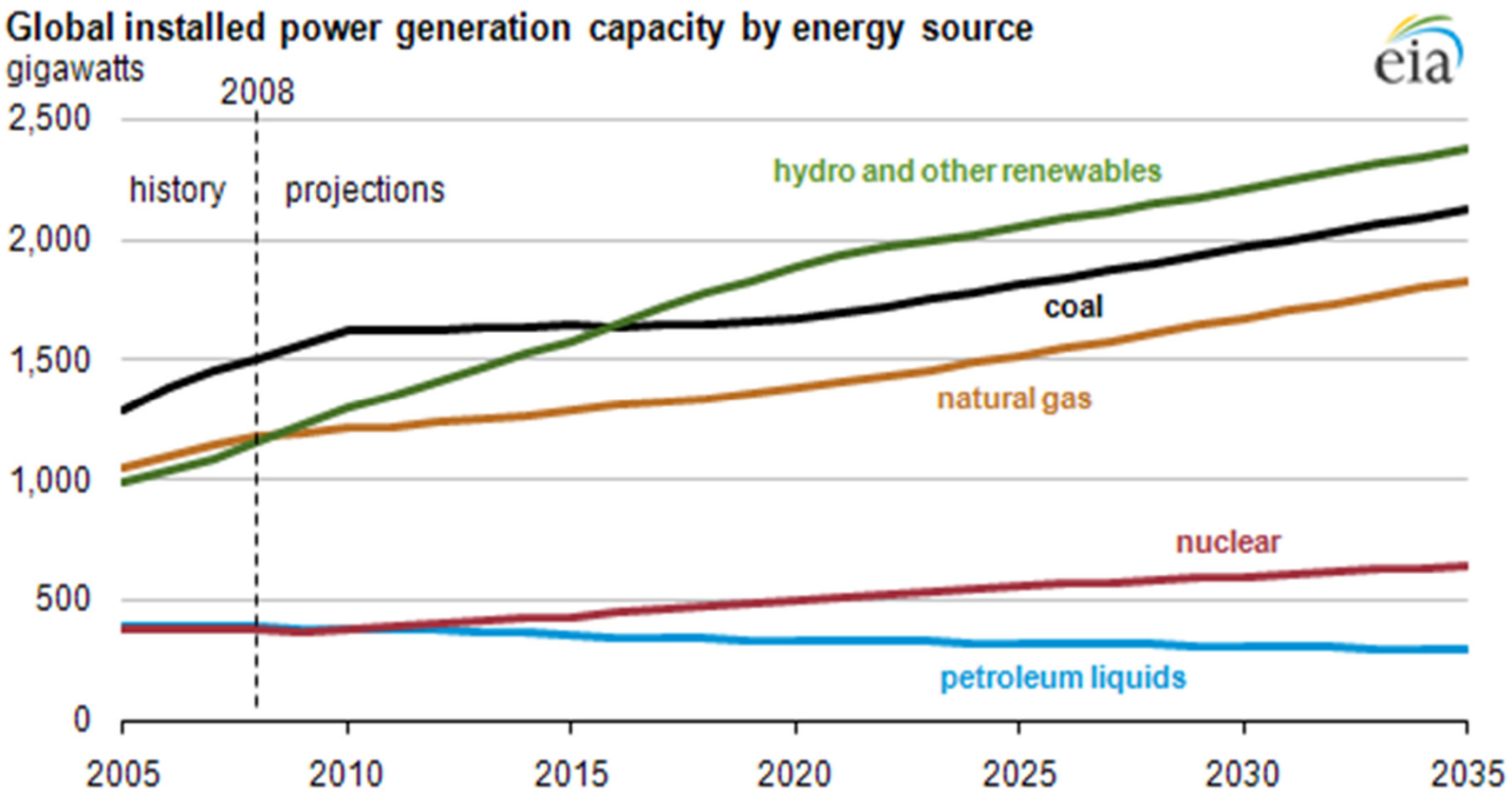
World Energy consumption



Ref: BP Statistical Review of World Energy - 2013

ALSTOM

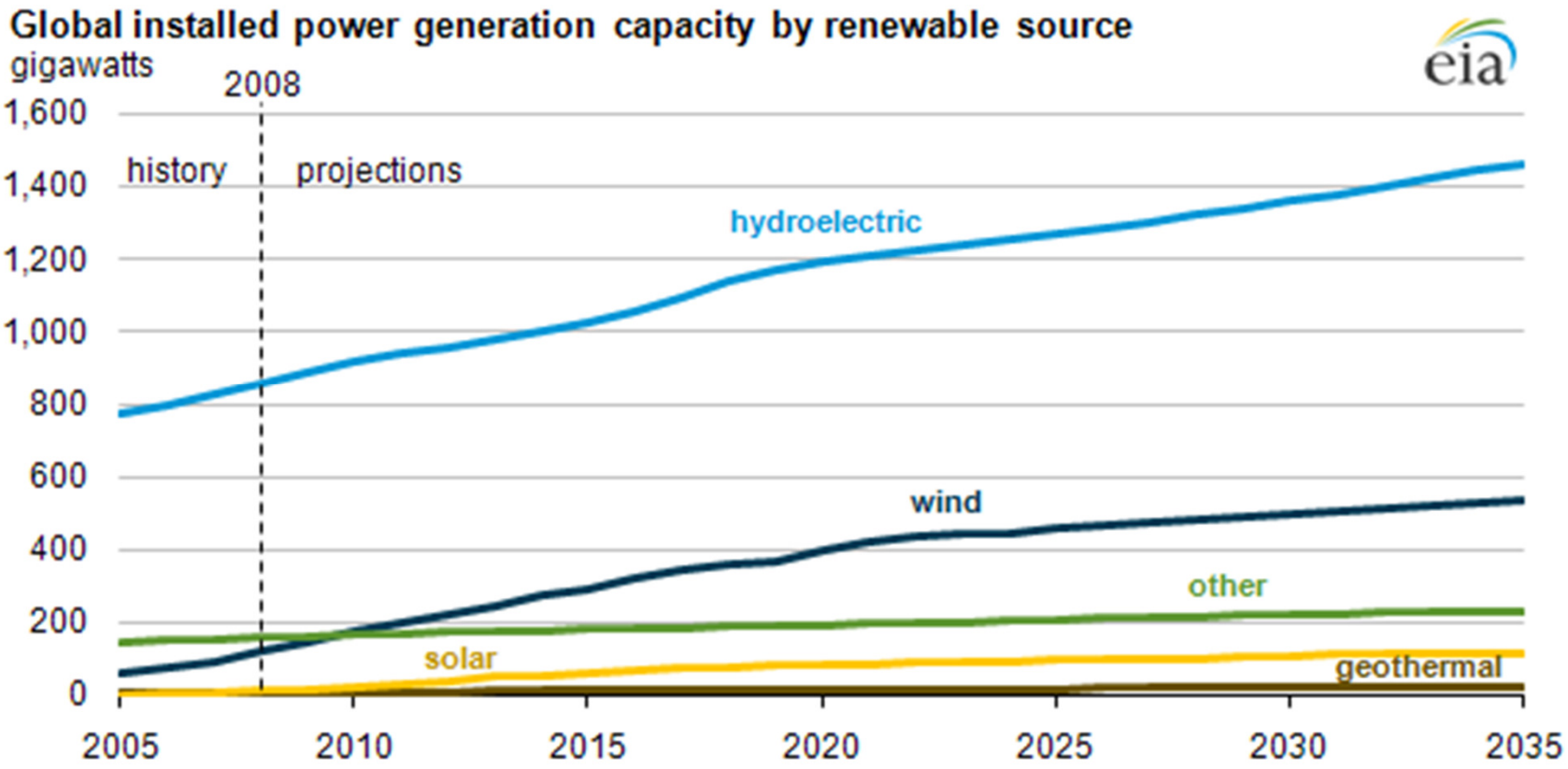
Renewable energies showing the highest growth in electricity generation capacity



Ref: U.S. Energy Information Administration, International Energy Outlook 2011

ALSTOM

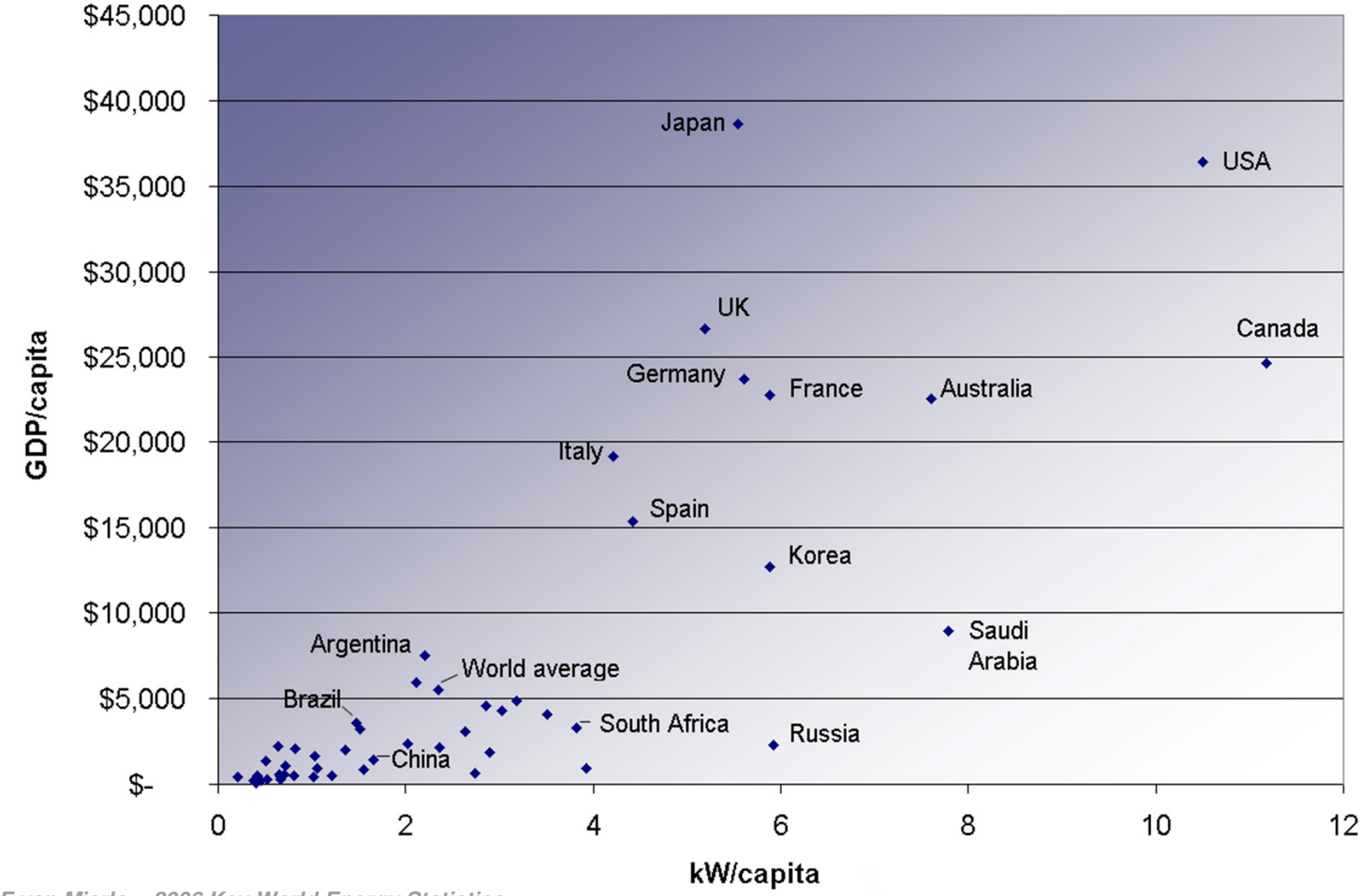
Renewable energies mix



Ref: U.S. Energy Information Administration, International Energy Outlook 2011

ALSTOM

Energy consumption versus GDP



Ref: F van Mierlo – 2006 Key World Energy Statistics

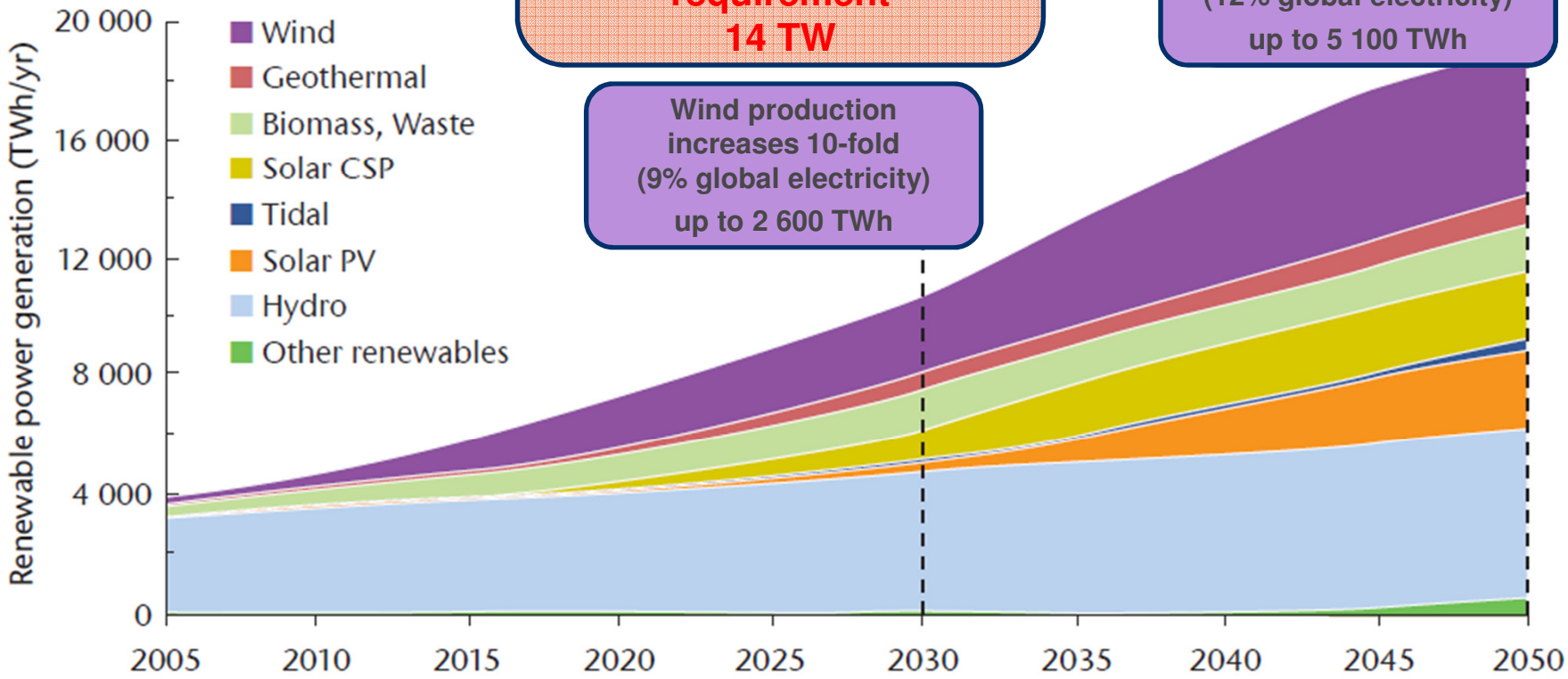
ALSTOM

Electricity from renewable energy sources up to 2050 in the ETP 2008 BLUE Map scenario (updated 2012)

to be compared with a « conservative » global increase in energy production capacity requirement 14 TW

Wind production increases 20-fold (12% global electricity) up to 5 100 TWh

Wind production increases 10-fold (9% global electricity) up to 2 600 TWh



Ref: IEA – ETP 2008 BLUE Map scenario

ALSTOM

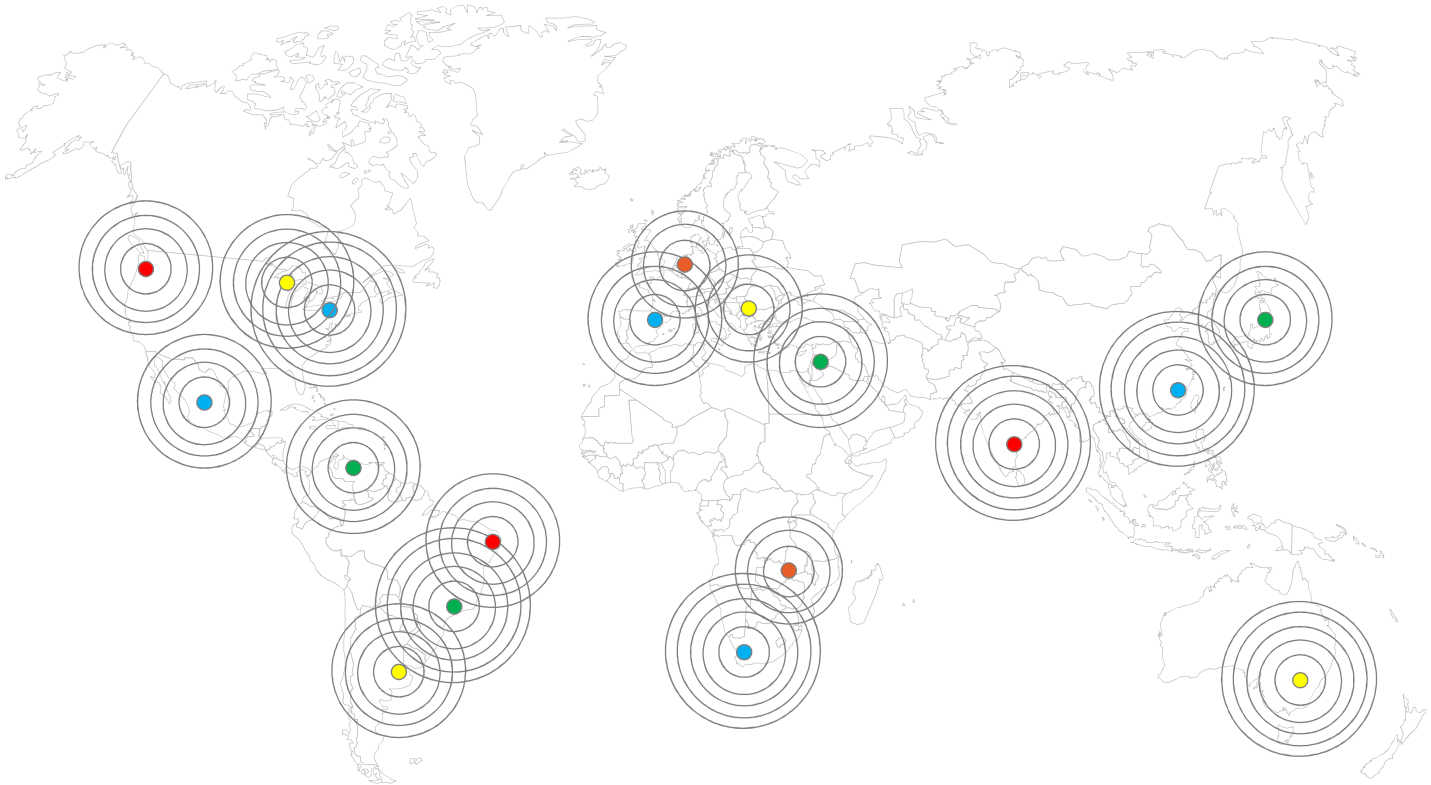
Key drivers
Urban migration

A planet of smarter cities:

1900 < 20% world population lived in cities, 0.3 billion people

2007 > 50% population lived in cities, 3.3 billion people

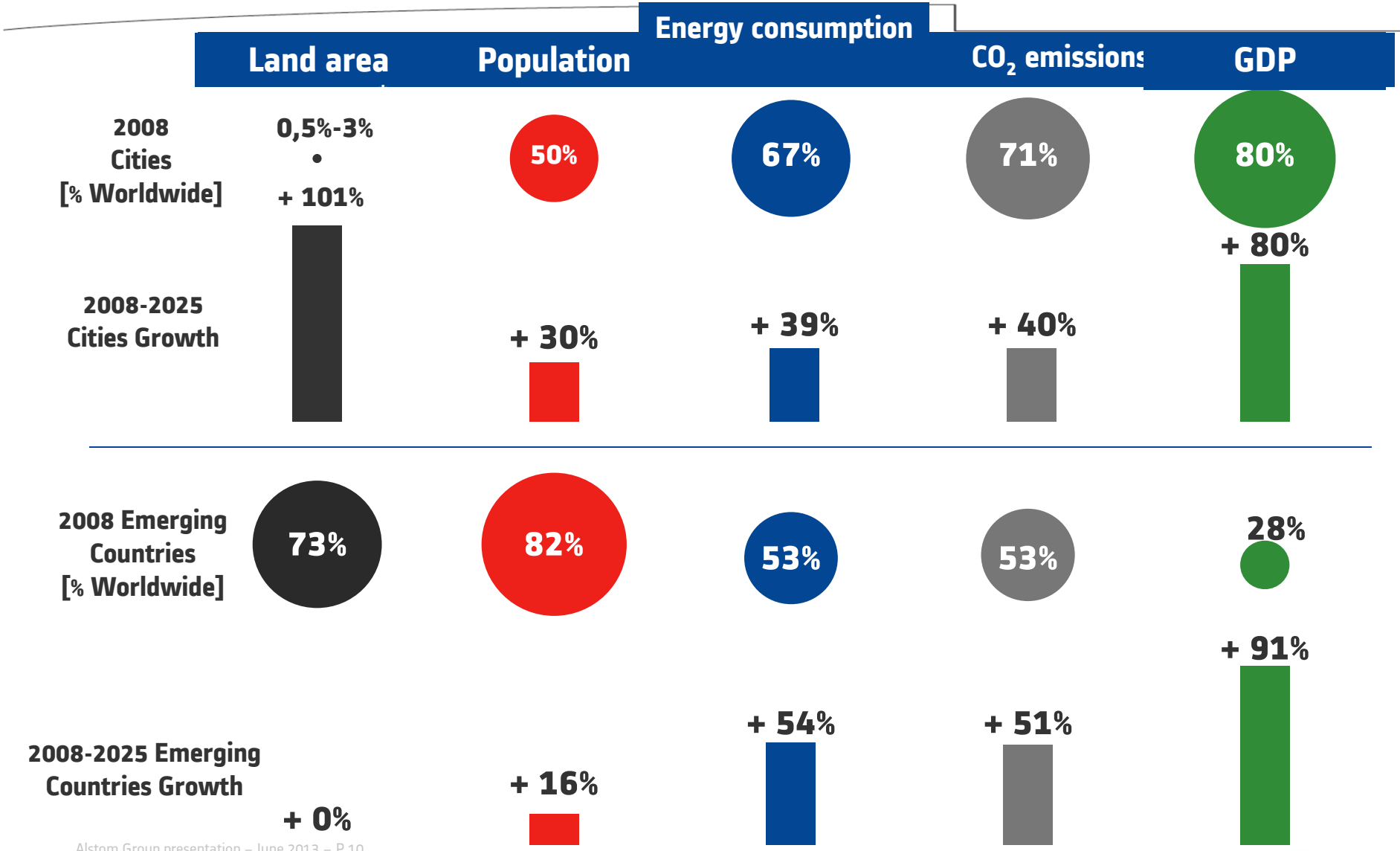
2050 > 70% will be city dwellers, 6.4 billion people



ALSTOM

City trends …

Cities and developing world statistics



Sources: World Bank, EIA, UNDESA

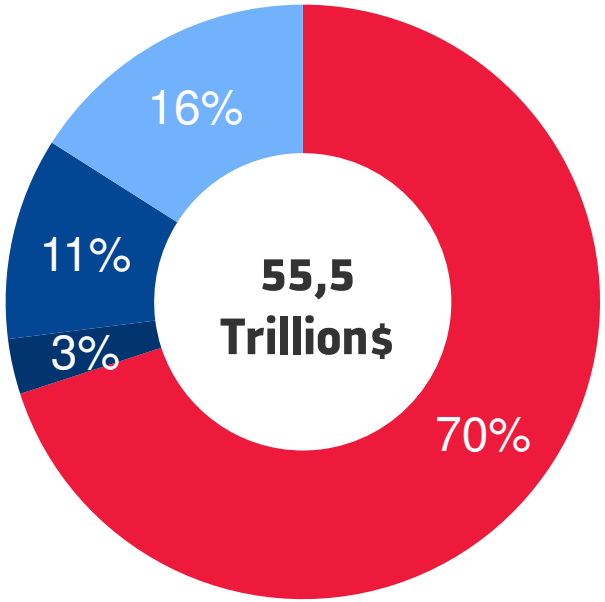
ALSTOM

Main issues for tomorrow…

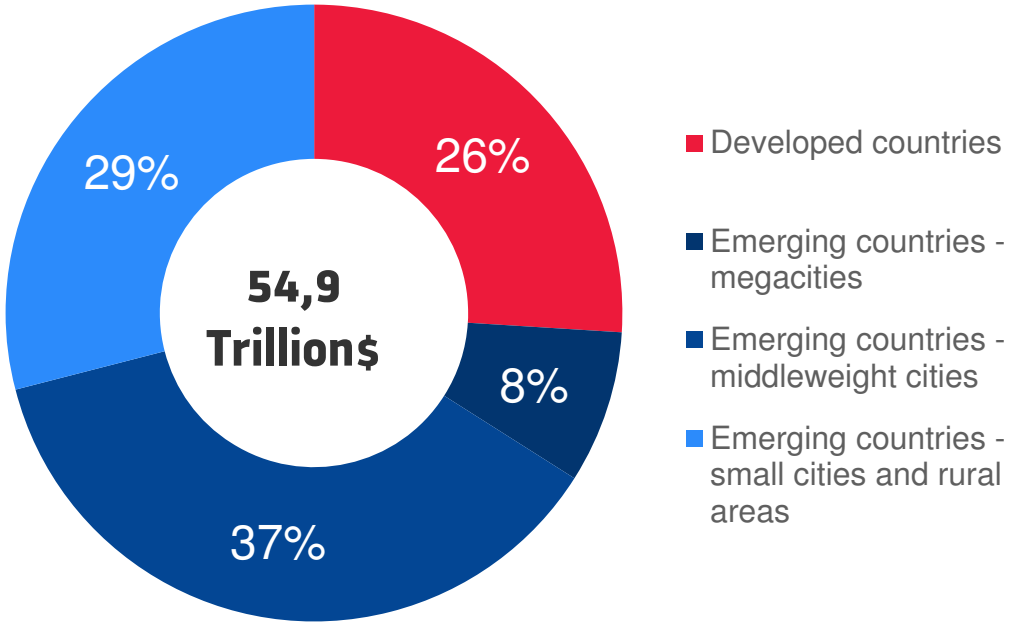
Cities growth & GDP

Close to **50% of the GDP growth worldwide** from 2007–2025 come and will continue to come from **Cities in Emerging Countries**

GDP, 2007



GDP Growth, 2007-25



ALSTOM

Agenda

Context and Forthcoming Trends… What if?

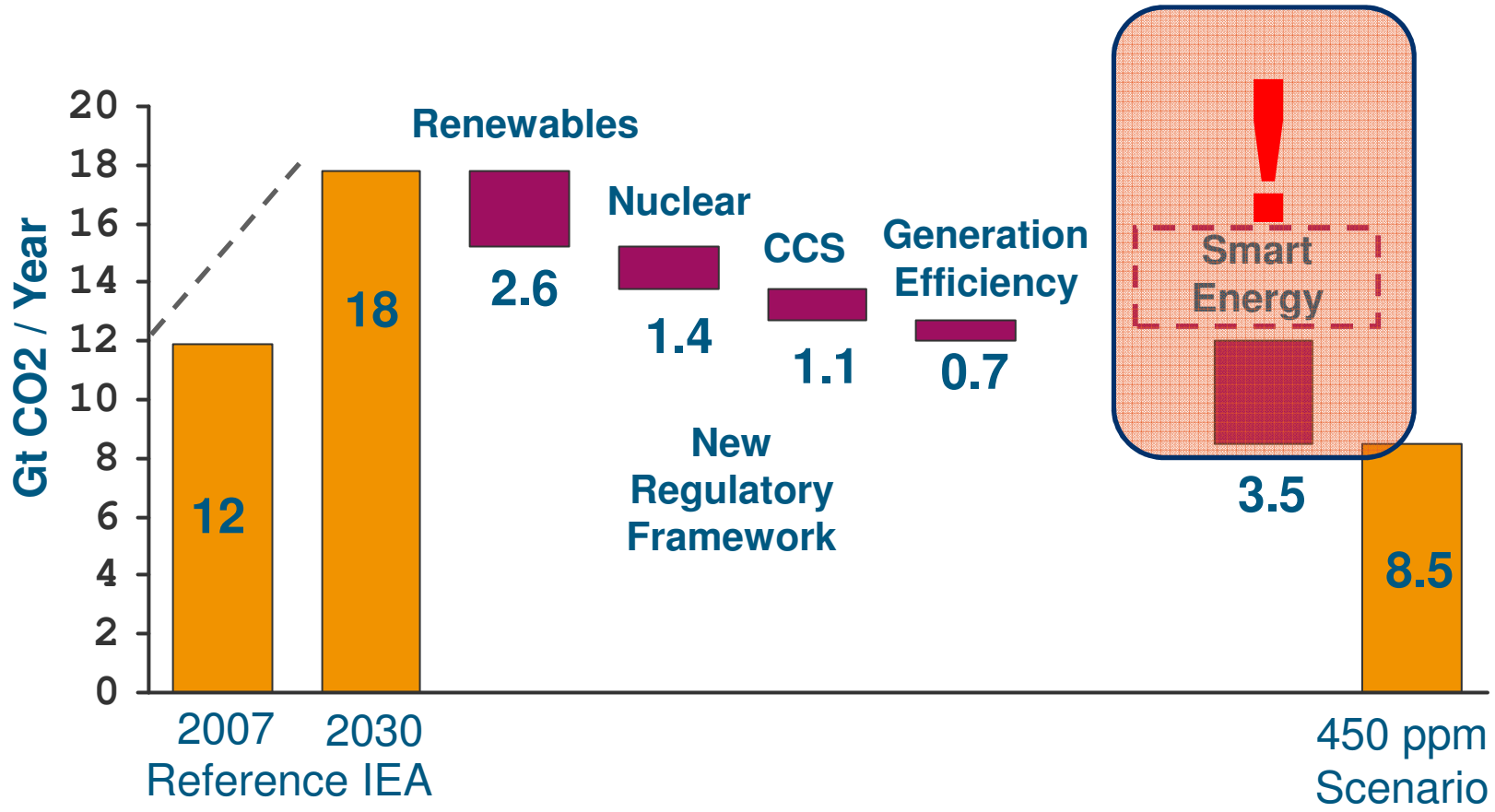
How to adapt?

Which challenges?

Which “enablers”?

ALSTOM

Smart Energy Systems are critical for CO_2 footprint reduction



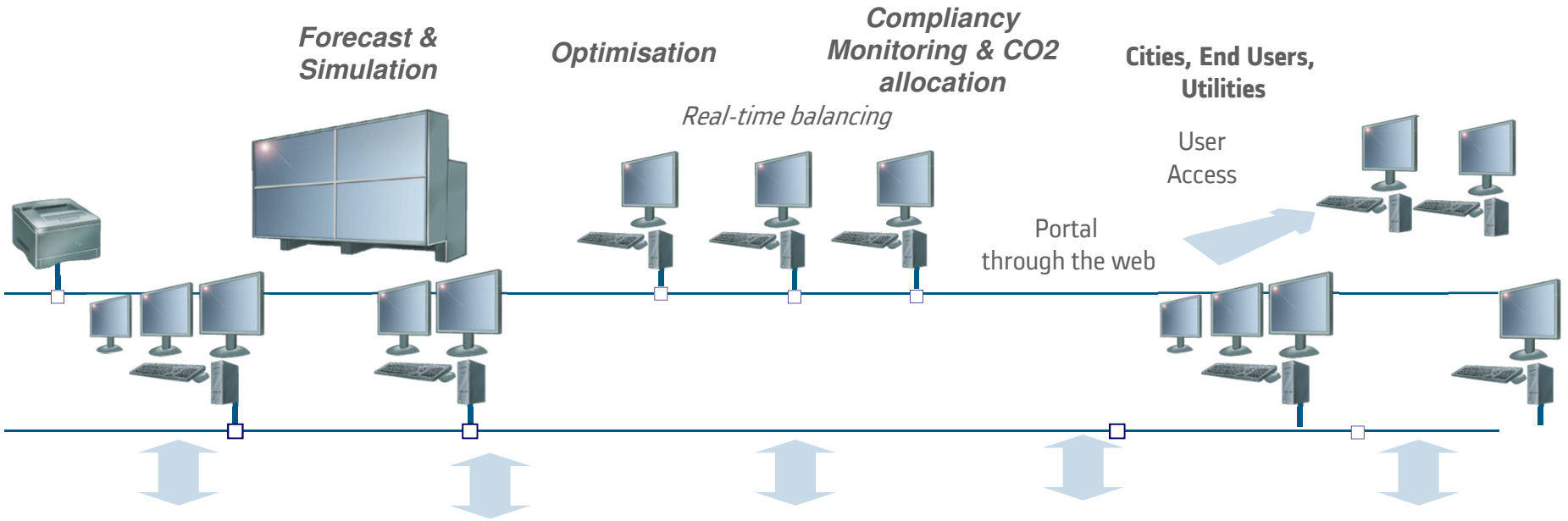
ALSTOM

And so, what?...

- We are reaching the system's limit : ***limitation*** and ***mitigation*** constraints are leading to ***negotiation***
- Prospectivists expect a smart cities evolution similar to that of the internet
- Convergence can easily become the incumbent playground
- Communication and Energy will become co-operative systems
- Largest silos: *Smart Grids, Smart Transportation, Smart Public Services/* Smallest: *Smart Buildings*
- Estimates vary... $100b (2020) - $1000b (2016)
- Projects are currently driven by developed countries but... 90% of population growth is expected in emergent markets
- No current market for integrated solutions

ALSTOM

CO_2 reduction will require the optimisation of energy & transportation usages



Urban Renewables

CHP / Biomass

Energy Positive Buildings

Energy Positive Infrastructures

Storage Infrastructures

ALSTOM

Ecosystems will evoluate…

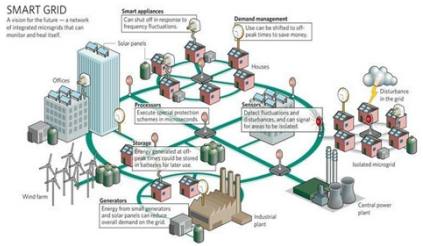
…we need a « smart glue »

Sustainability and Environmental Impact Awareness

A new energy mix to invent for a 9 billion inhabitants planet

Clean Power

Smart Energy Use
Renewable
Flexibility
Worldwide balance to share resources



Smart Grid

Integration of intermittent energies
Improvement of grid reliability and stability
Optimisation of electricity distribution

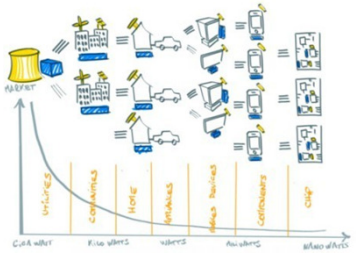
Mobility

Efficient urban mobility
Rational long distance connection
A PPP world (Financing Needs)

Digitalization

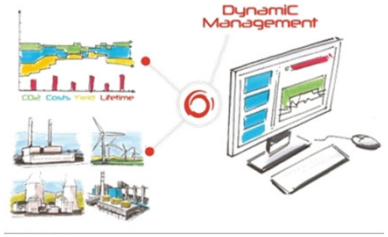
Trend towards a fully digitalised world

Control at a fingertip



Fully connected world
Supervision and Information
Hyper Connectivity & Cyber Security

Manage Complex World



Multiplications of Stakeholders
Flexibility and Adaptability
Distributed Intelligence

Service Oriented

Sustainable Maintenance & Operation
Virtual environment

ALSTOM

Shaping the Smart Grid

ALSTOM

Why are smart cities so important?

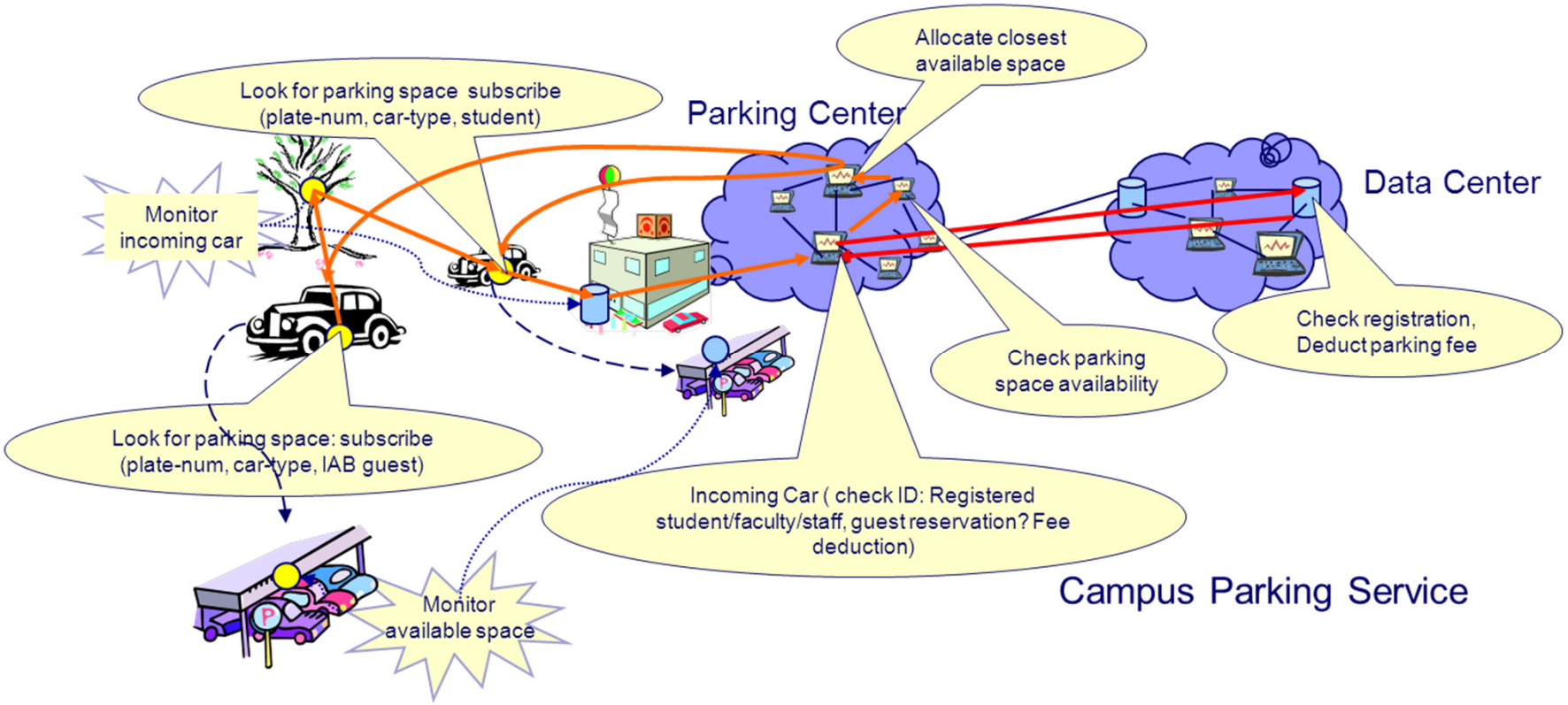





- The biggest challenge today
  - find the right combination of technologies to meet specific application needs
  - allow scale-up and replication. A pre-requisite in an integration between players
- Smart City Operating Systems could be the perfect glue with the development of Smart City applications
- Political involvement is needed to make the barriers crumble

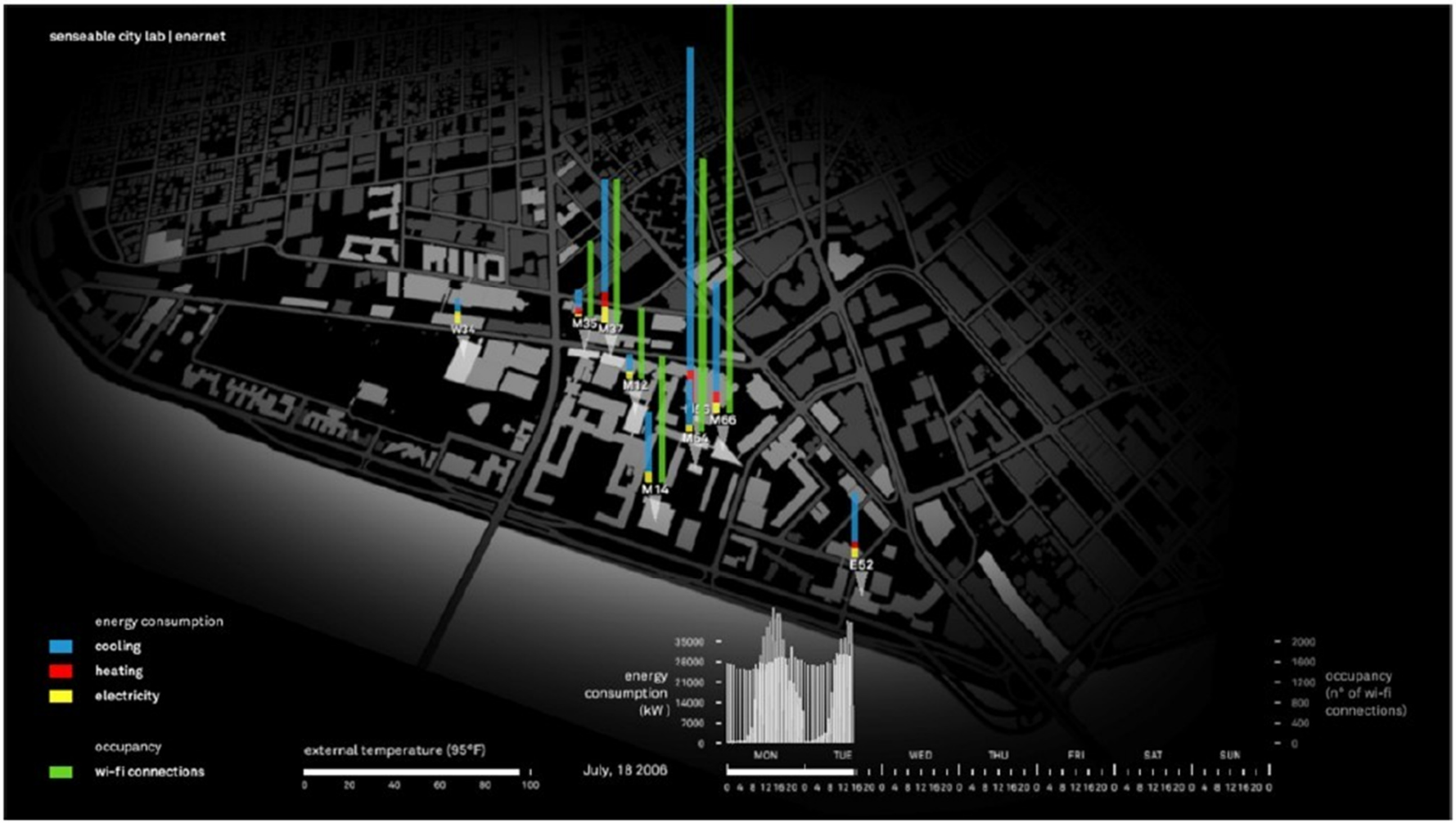
ALSTOM

An example of a Smart System



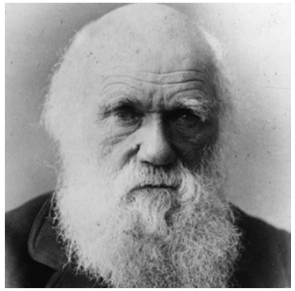
ALSTOM

New trends…



The energy profiles and WiFi activity of 9 buildings within the MIT campus on 18th July 2006.

ALSTOM



"In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed"

Charles Darwin

Dominant social trends

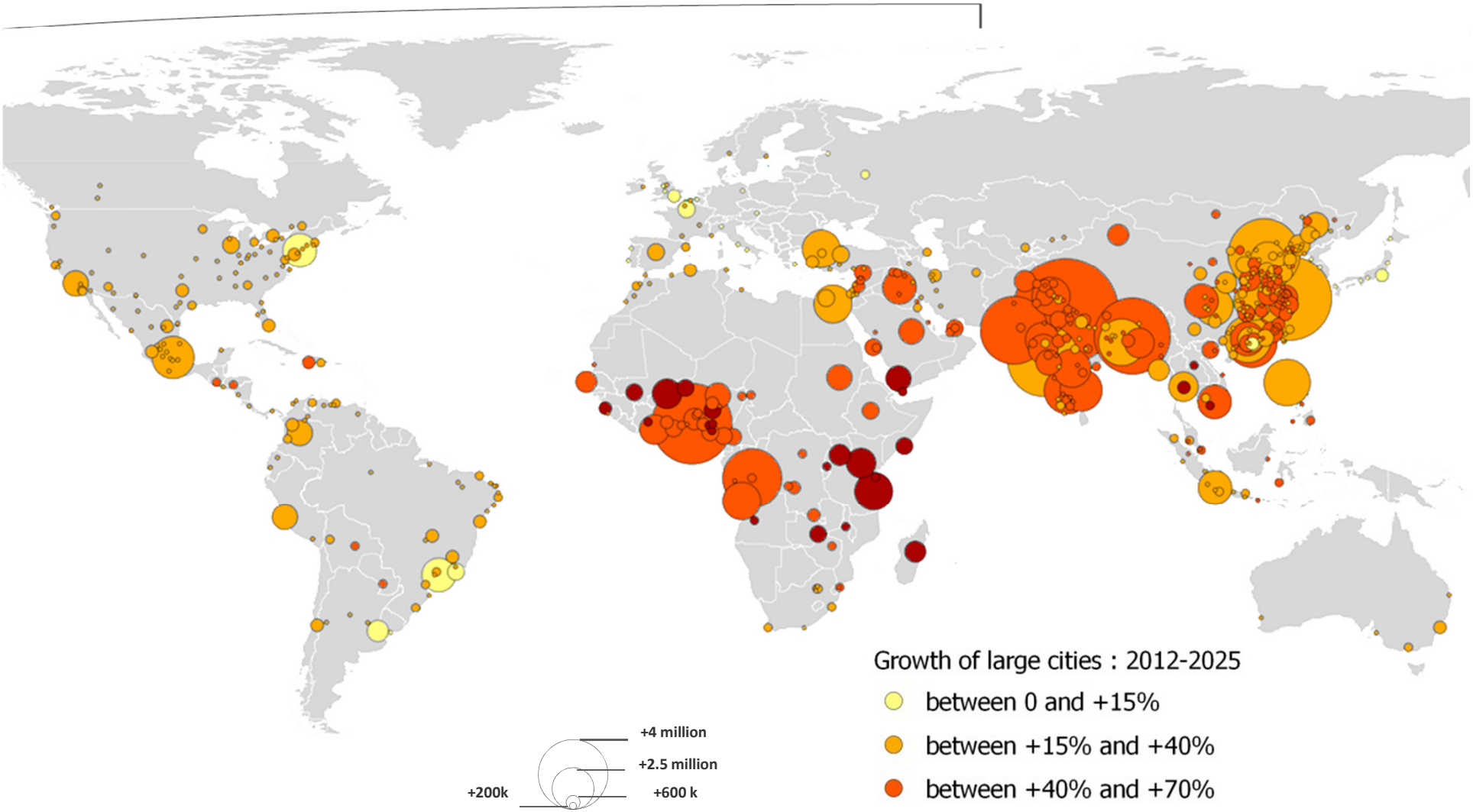
- **World population is projected to increase to at least 9 billion by 2050**

- **At the same time, current trends indicate an steep increase in living standards and a fast growing middle class around the world**

✓These two mega-trends will have profound implications, and the way they are managed will be one of the key determinants of prosperity and peace in the decades to come

✓A number of factors are important in this respect

City trends …
Cities growth map



UNDESA - World Population Prospects (2010)

ALSTOM

Agenda

Context and Forthcoming Trends… What if?

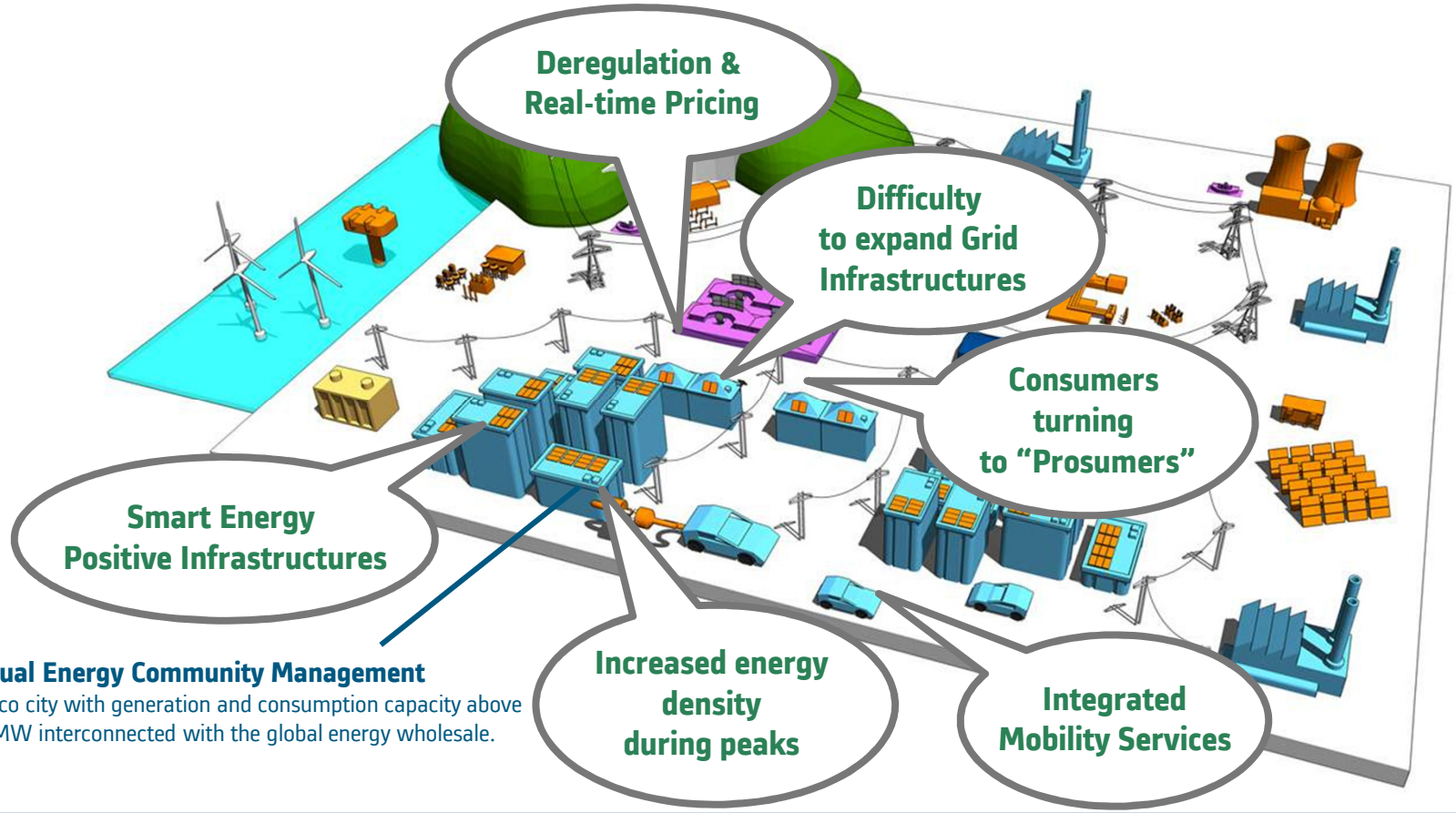
How to adapt?

Which challenges?

Which “enablers”?

ALSTOM

Growing constraints in city energy infrastructures



Virtual Energy Community Management
An Eco city with generation and consumption capacity above 100MW interconnected with the global energy wholesale.

Emergence of new Virtual Power Plant concepts

Bouygues Immobilier

econoving

ALSTOM

City trends…

- The biggest challenge today
  - find the right combination of technologies to meet specific application needs
  - allow scale-up and replication. A pre-requisite in an integration between players
- **SCOS** could be the perfect glue with the development of Smart City applications
- Political involvement is needed to make the barriers crumble
- Many people compare the development of Smart Cities with the Internet

ALSTOM

Agenda

Context and Forthcoming Trends… What if?

How to adapt?

Which challenges?

Which “enablers”?

ALSTOM

A word-wall picturing …a complex entanglement

smart and real-time adaptive operating systems
(model evoluates while operating)

arbitration

hierarchy

local

global

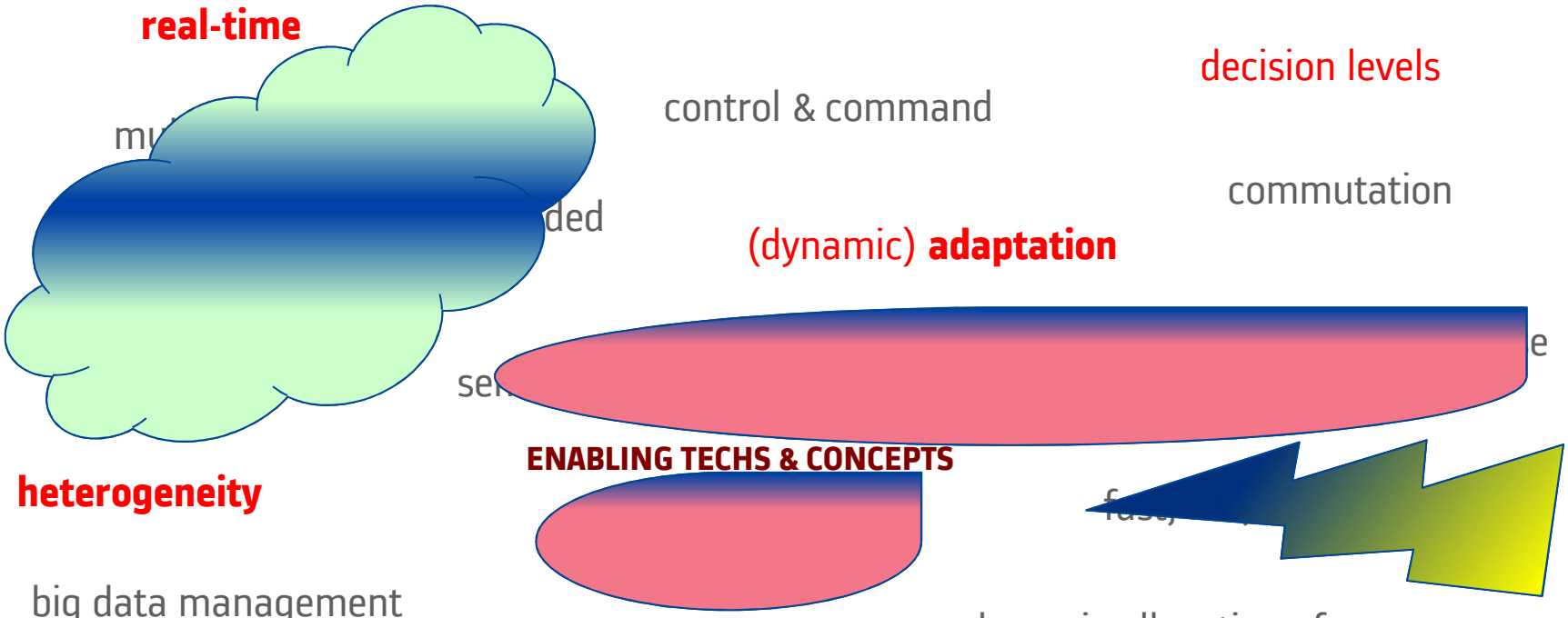
real-time

decision levels

control & command

commutation

(dynamic) **adaptation**



heterogeneity

big data management

dynamic allocation of resource

big data treatment in flows
(more than in stock)

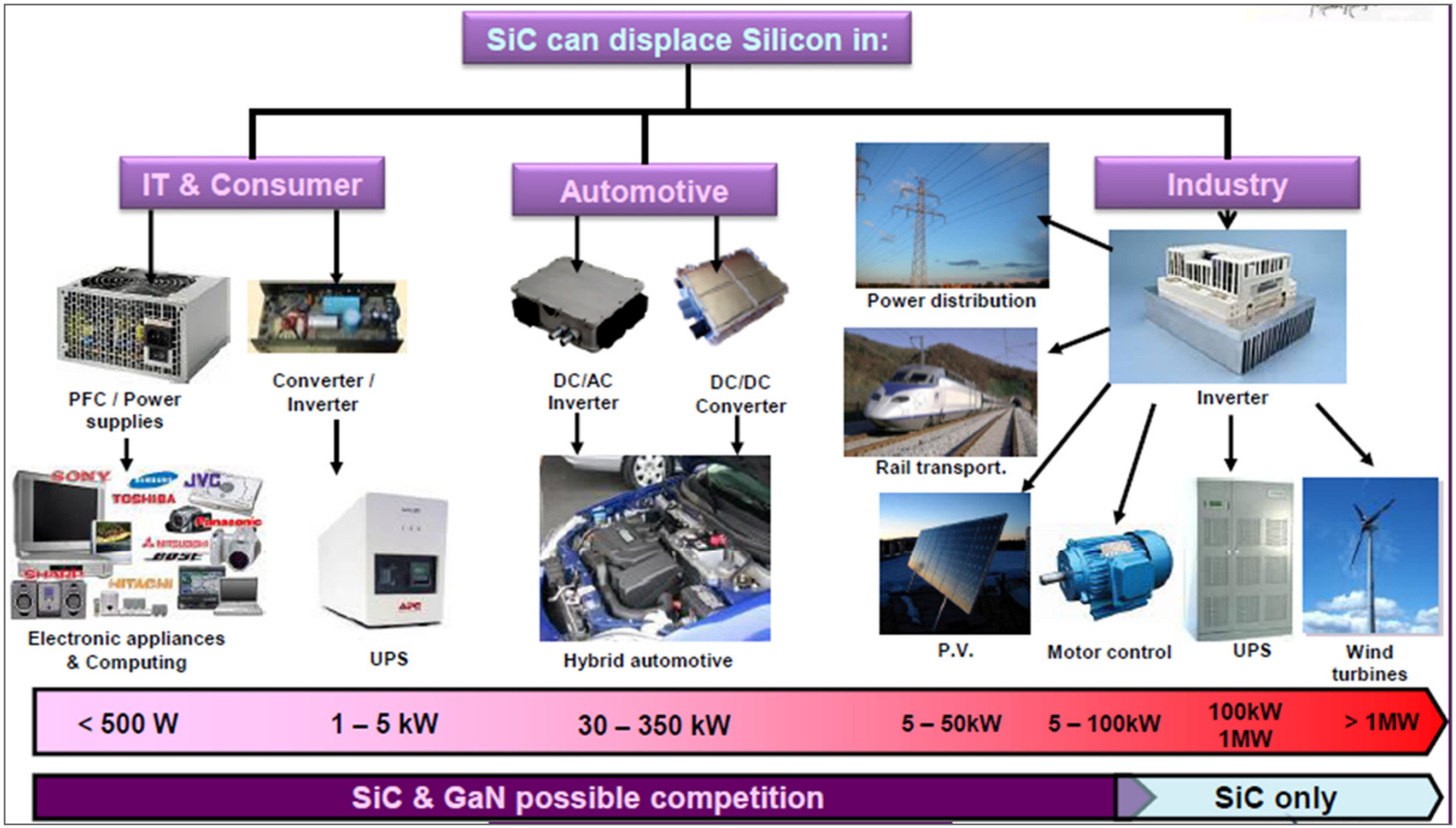
optimisation

combination

negociation

ALSTOM

Power electronics



Power Electronics
Situations, Opportunities and Risks

Smart territories will need smart tools and smart tools rely on

- Information technology and sensors (to control and observe)
- Large computing and data analysis capability (to predict and plan)
- Flexibles actuators/reactive systems (to transmit decisions and interact)

Last 20 years of " information revolution" unlocked innovation solutions to replace /substitute services given/proposed by the infrastructure sectors such as electricity networks, transportations solutions...

This impact our businesses and adjacent ones and it will continue (toward more and more distributed markets? etc..)

ALSTOM

P.E @ heart of new growth areas

Critical products' performances depend on P.E. pieces

Thermal

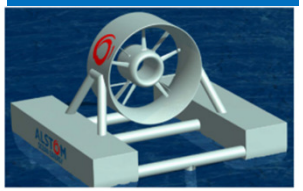
Flexible Plants: at various loads, minimising fuel consumption (via VFD)

Flexible high efficiency products: via cost effective combisystem concepts

Serivces: PE equipment used to penetrate other fleets (High margin) maintenance contract- Troyan horse to gain skills on our products is already threatening in Nuclear

Hydro Pump Storage variable speed drive: to maximise efficiency (capital intensive)

Renewable



Offshore **Wind Converters** to connect with low perturbations to networks

Ocean converters to link with networks

Innovation/ Technology leadership

Smart Grids (intelligence, distribution, interconnection)

Traction chain (incl. Motors+ converters) (source of innovation and breakthrough to reduce volume and weight to benefit / Differentiate product value proposal)

Substations to capture and reuse breaking energy (energy saving features/improve operation costs structure)

HVDC (main drivers : technology and reliability ; major difficulties : circuit breaker, Very high voltage, connection with AC)

Core solutions to Smart Territories

Transport

Grid

Energy storage

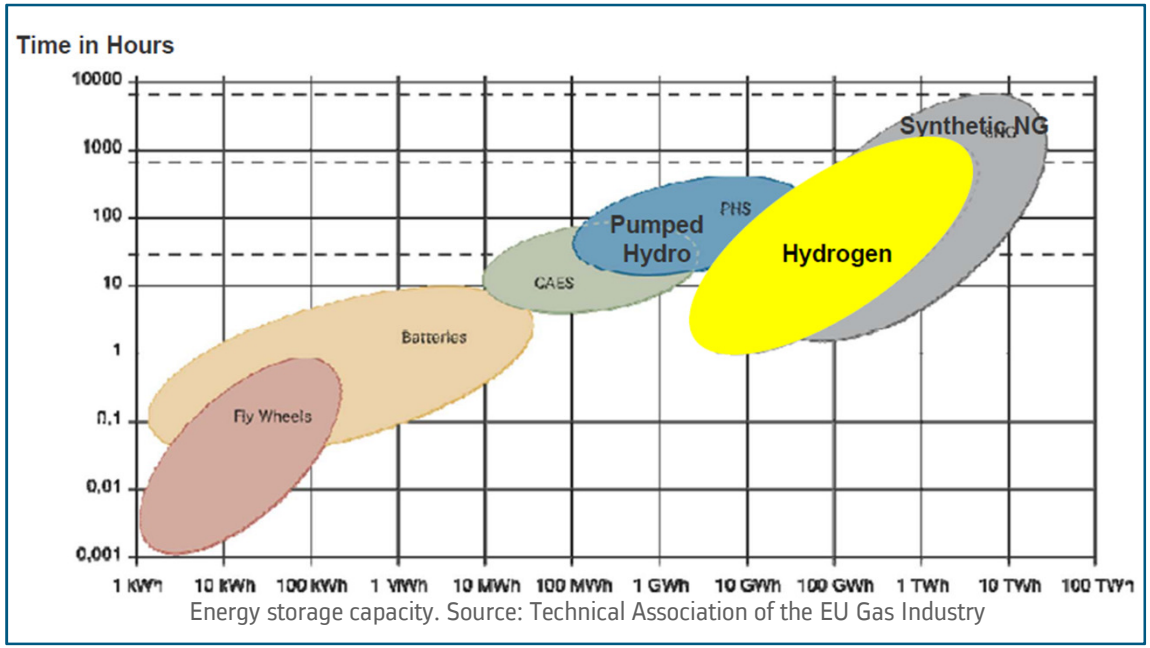
Expected breakthrough in large –scale energy storage

Alstom is conducting research into a variety of possible energy storage capabilities featuring different time constants, scales, materials , equipment, etc.

Technologies mix for hybrid

and flexible solutions:

- Hydrogen
- Battery technologies
- Hydro storage
- Flying wheels
- Supercapacitors
- Compressed air



Energy storage capacity. Source: Technical Association of the EU Gas Industry

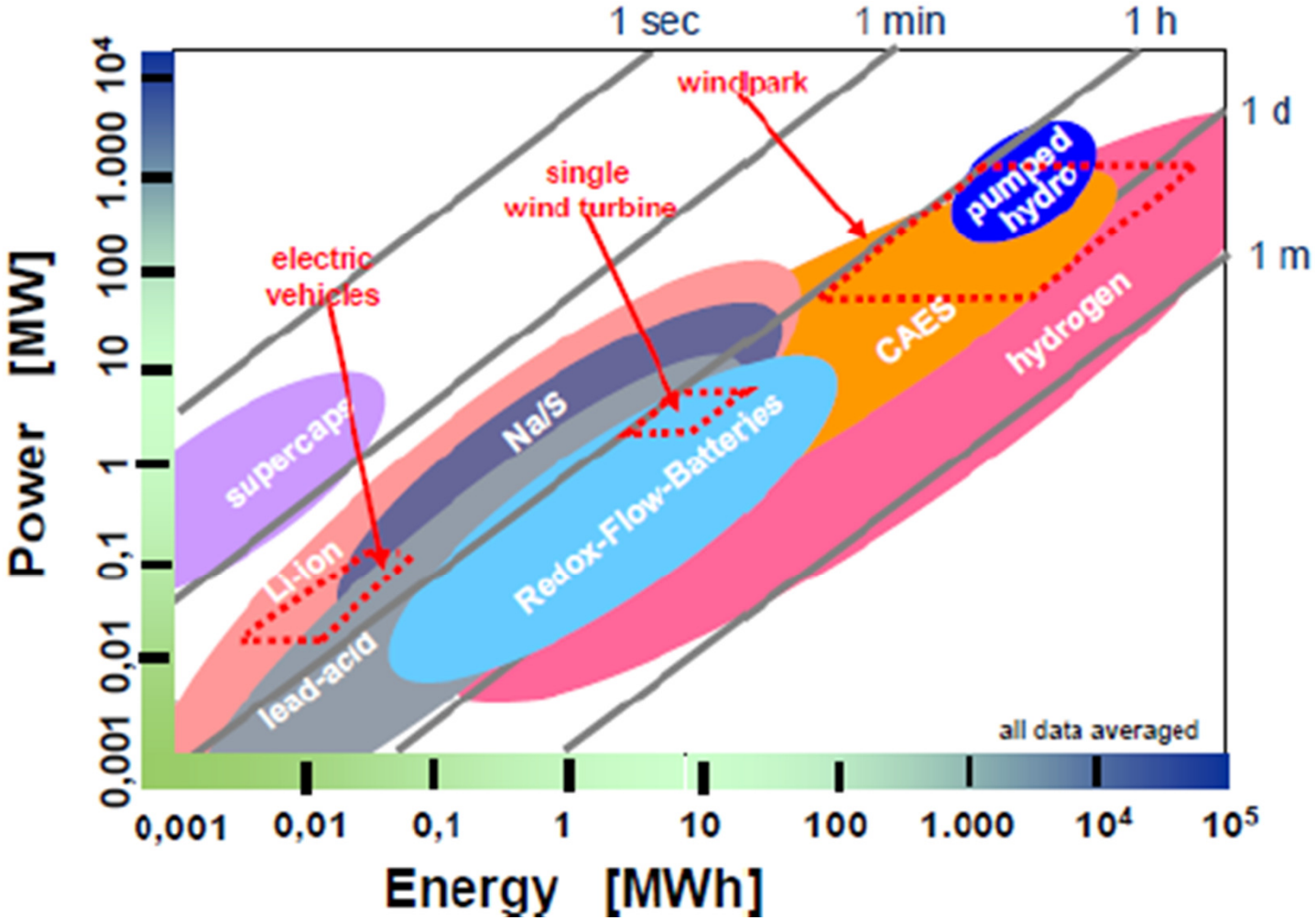
ALSTOM

Energy storage

❑ 1 kg coal	8 kWh
❑ 1 kg wood	4 kWh
❑ 1 kg oil	10 - 12 kWh
❑ 1 kg natural gas	10 - 14 kWh
❑ 1 kg enriched uranium	600 000 kWh
❑ 1 kg of water - 1000 m fall	0.003 kWh
❑ 1 kg Pb battery	0.03 kWh
❑ 1 kg lithium battery	0.25 kWh

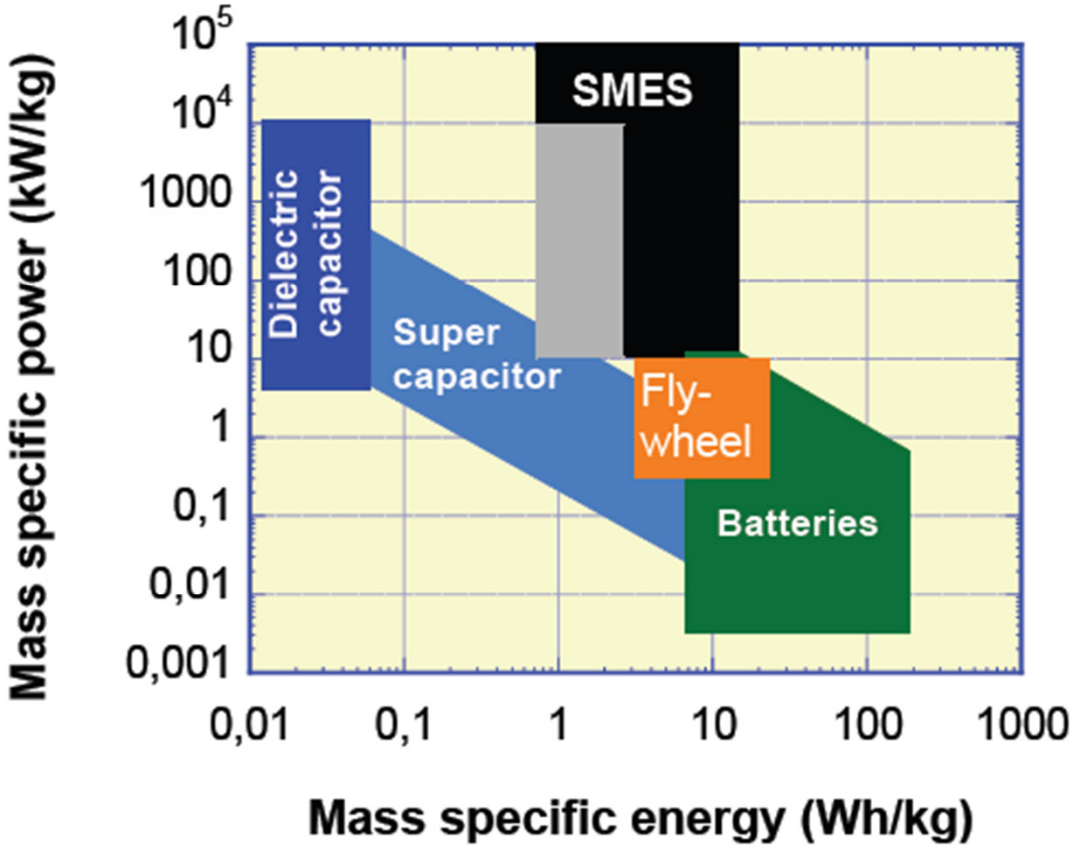
ALSTOM

Energy storage



ALSTOM

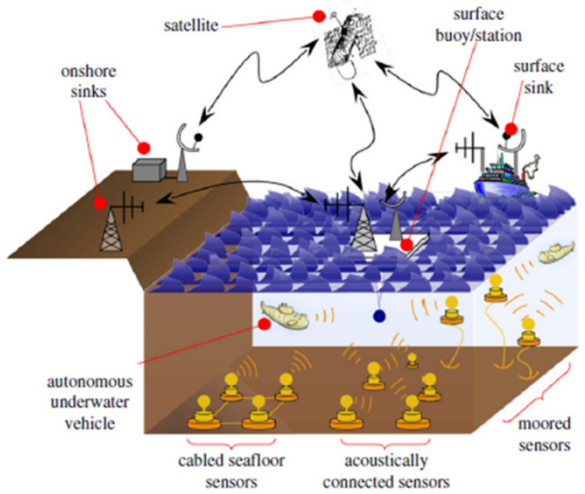
Energy storage

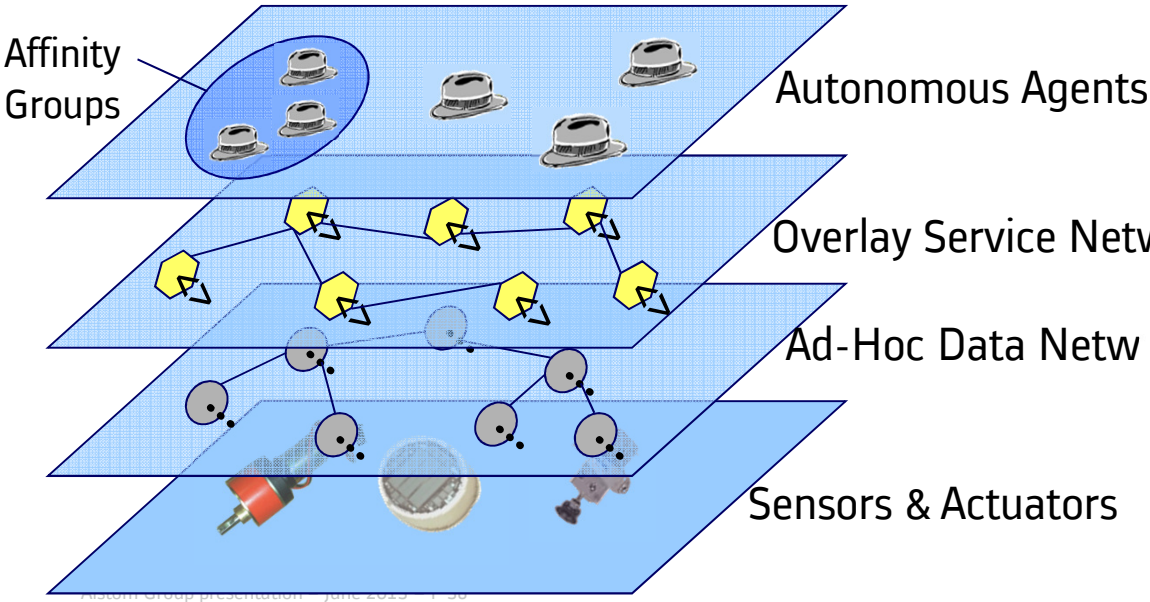


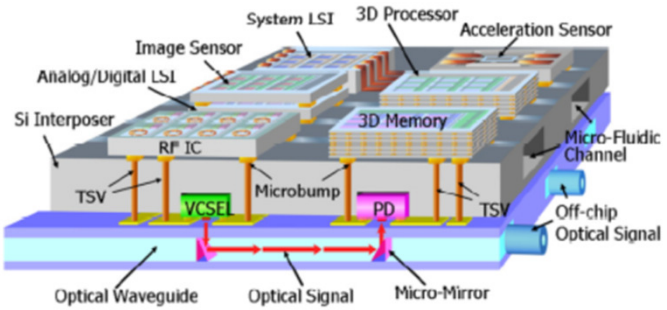
Ragone chart: Performance comparison of storing devices

ALSTOM

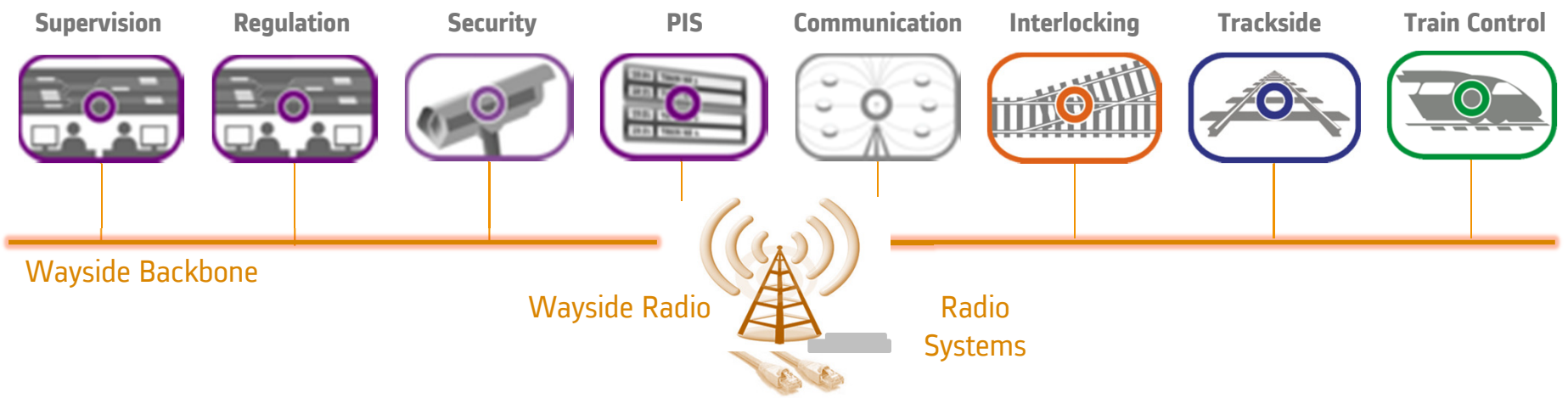
Smart Sensors Systems







Network and Telecom, the glue



Trainborne Equipment
ATP – Voice – PACIS - Security

ALSTOM

As a temporary conclusion…
this forthcoming ecosystem will be

- **distributed**
- **composite** & **complex**
- **systemic**

and ***real-time***

ALSTOM

www.alstom.com

With Alstom, preserve the environment.
Is printing this presentation really necessary?

ALSTOM