International Energy Agency
1974•2014

How2Guide for Smart Grids in Distribution Networks

Simone Landolina

Global Energy Interconnections: Smart Grids and Beyond

22 June 2015

Beijing, China

www.iea.org

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IEA Roadmaps and How2Guides

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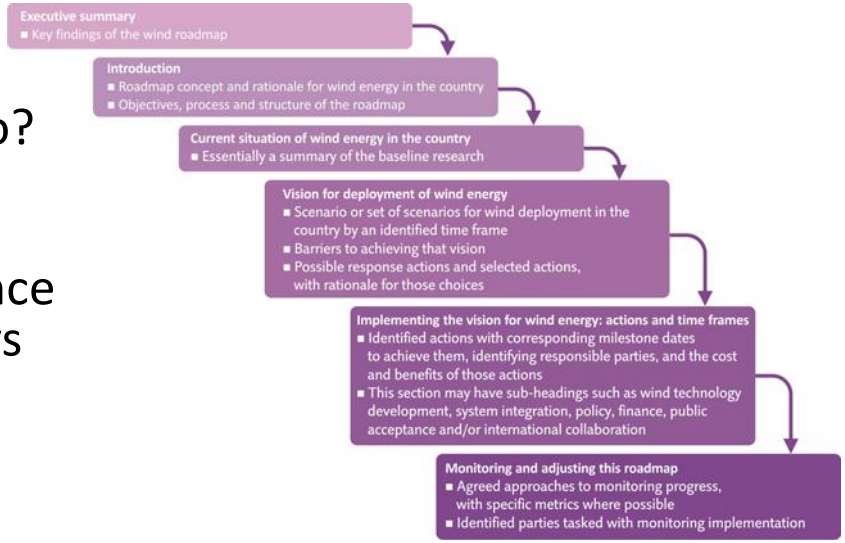
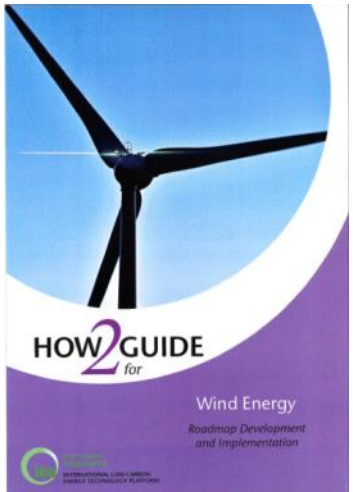
IEA Global Roadmaps

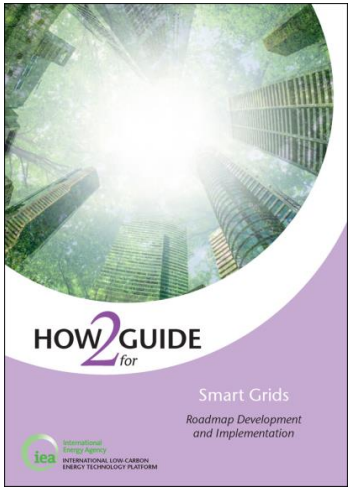
- Where do we need to go?
- Where are we today?
- Global vision and guidance on deployment pathways



IEA Technology Platform *How2Guides*

Provide practical information for policy makers and planners to establish a national or regional technology-specific roadmap





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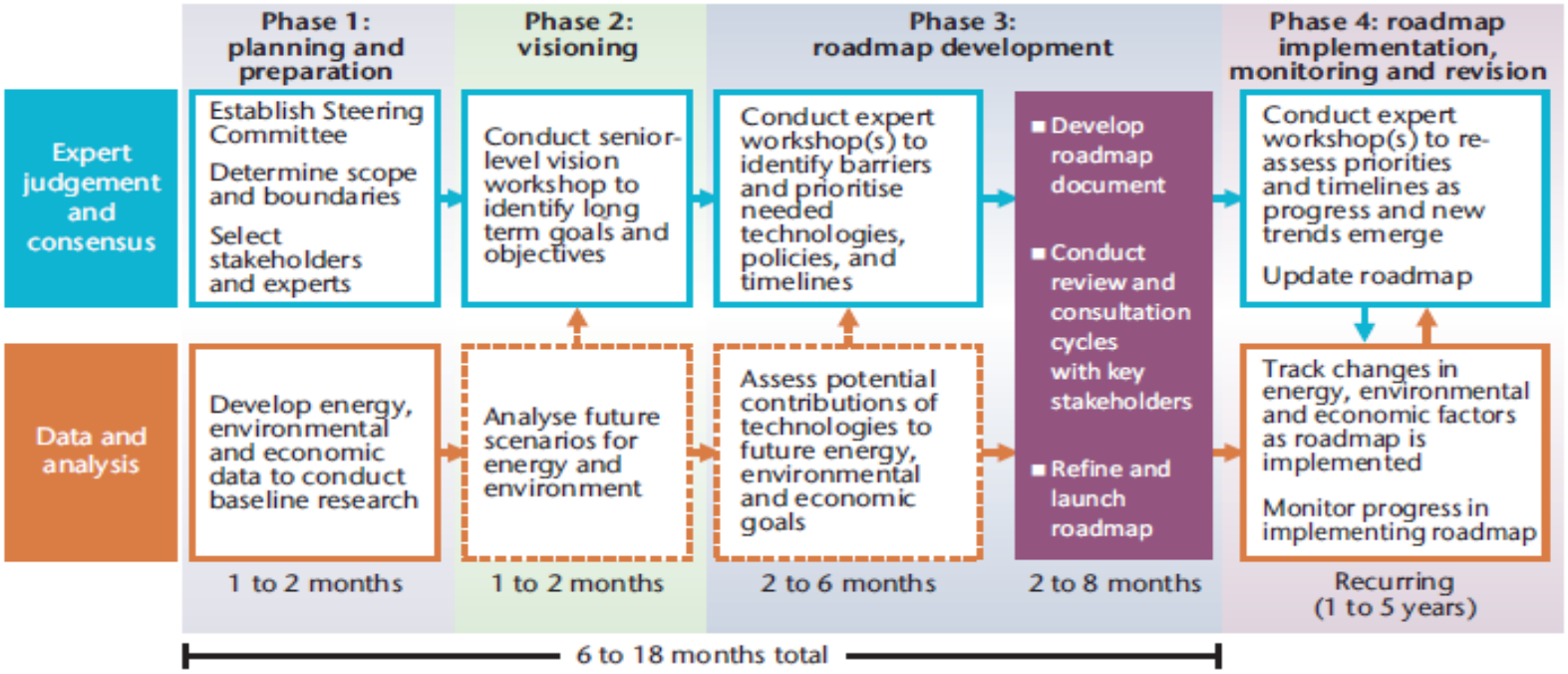
How2Guide framework

- Provides tools and steps for decision makers to implement a strategic technology roll-out



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How2Guide for Smart Grids

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Why are we doing this?

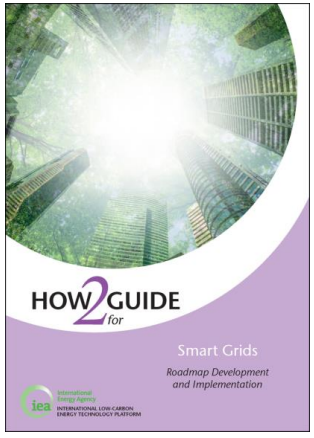
- To scale-up IEA capabilities to provide support to countries for national / regional smart grids roadmap development
- To enhance the impact of the IEA's technology roadmap programme

Is this only for IEA Members?

- Not at all – key Partner countries and other emerging economies are key How2Guides contributors and audience
- Countries that already have smart grid roadmaps can use it as a tool for internal revision and to accelerate technology deployment

Why focus on distribution networks?

- Great potential and need for development at this time
- Transmission system "smartening " is already quite advanced
- Key role to integrate renewables and reduce losses



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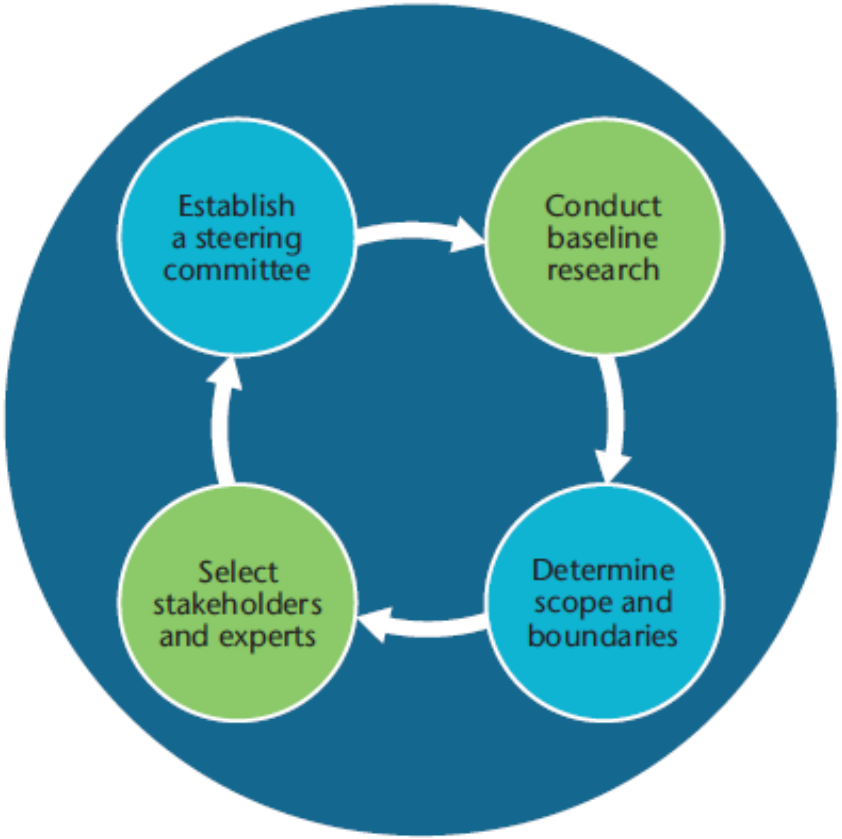
Phase 1: Planning and preparation



- Determine physical and institutional infrastructure that support technologies and enable deployment
- Select key stakeholders at varying phases and levels of technology deployment
- Define “Smart Grids” !

A smart grid is an electricity network system that uses digital technology to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demand of end users (IEA, 2011).

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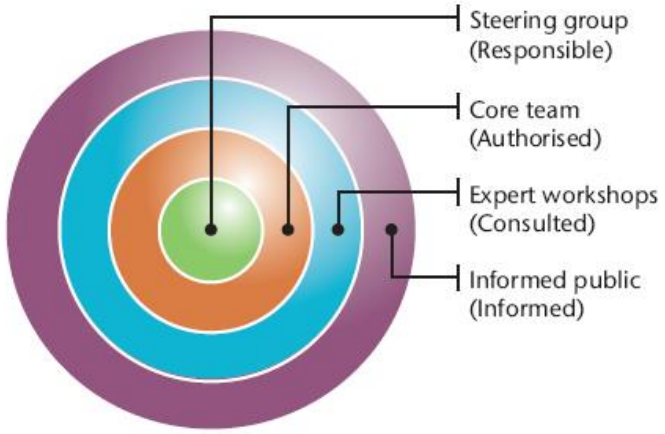
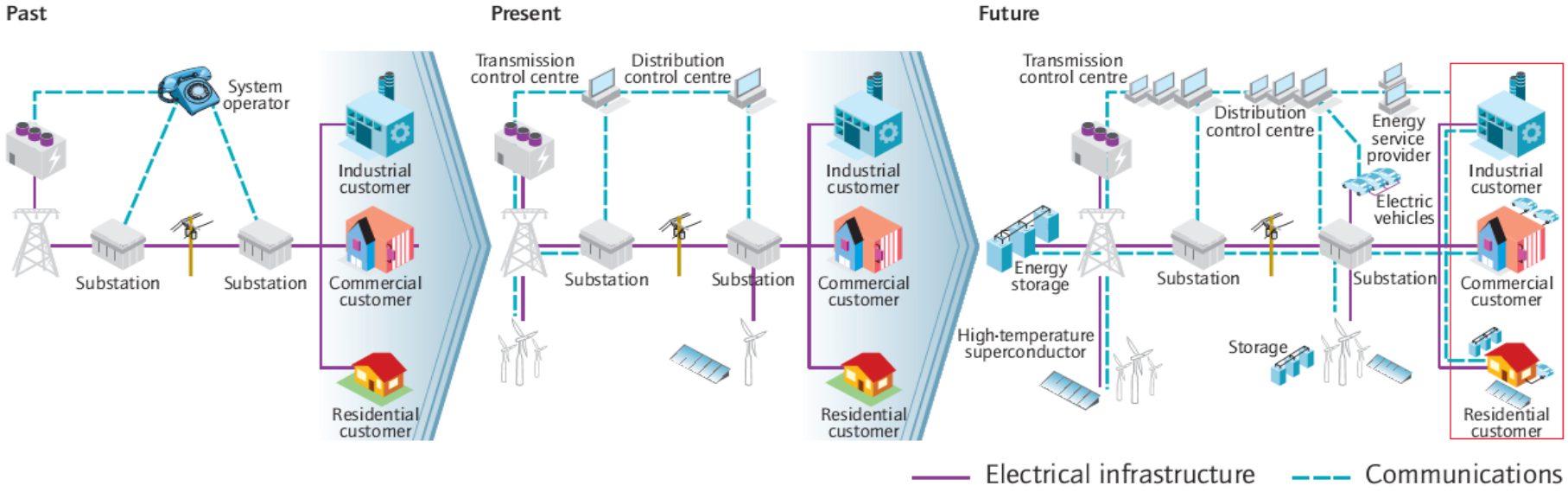
Phase 1: Planning and preparation

- Stakeholders have evolved with the "smartening up" of electricity systems
- 25 smart grid stakeholder types
- R.A.C.I. mapping





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Italy case study: smart grids applications and main stakeholders

STAKEHOLDERS

DSO		✓ Remote control and operation ✓ Automation and self healing ✓ Monitoring in Real time ✓ Planning and Maintenance	✓ Optimizing Network configuration ✓ DER monitoring ✓ Grid planning and mgt ✓ Voltage regulation NEW	✓ Outages management ✓ LV Network monitoring ✓ Fraud detection and balancing activities	✓ Monitoring and control of charging process ✓ Load flexibility enabled NEW ✓ Vehicle to Grid (V2G) Services enabled NEW
SYSTEM		✓ Information Exchange with the TSO ✓ Dispatching in emergency situation	✓ DER observability for the TSO enhanced ✓ Forecast of generation ✓ Generation curves to GSE ✓ DER control in emergency situation ✓ Local dispatching enabled NEW	✓ Load flexibility enabled NEW	✓ Load flexibility enabled NEW
CUSTOMER		✓ Outages fast restoration ✓ Trouble calls mgt with automatic response	✓ Unnecessary disconnection avoided ✓ Voltage quality improved ✓ Generation and consumption optimization enabled for LV prosumers NEW	✓ Reliable billing based on actual consumptions ✓ Flexible tariff structure ✓ Remote Contract management (activation/deactivation etc) ✓ Empowering customers with higher quantity and quality of info	✓ Interoperable and multi vendor EV charging ✓ Fast charge
MARKET		✓ Information Exchange with PA for city planning and decision making NEW	➢ Active demand enabled NEW ➢ Opening new markets for local DER dispatching NEW	✓ Metering data validation and settlement ✓ Fast and easy switching enabled ✓ Active Demand and VAS enabled by metering data NEW	✓ Metering data validation and settlement ✓ Market competitiveness enhanced through interoperable and multi vendor EV charging NEW

Source: ENEL, 2014

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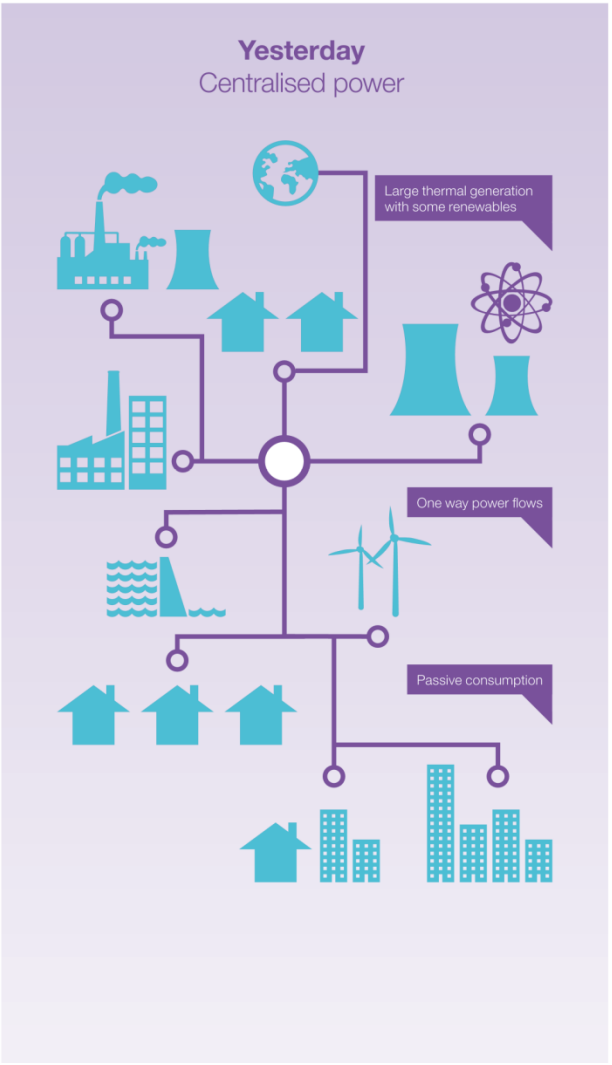
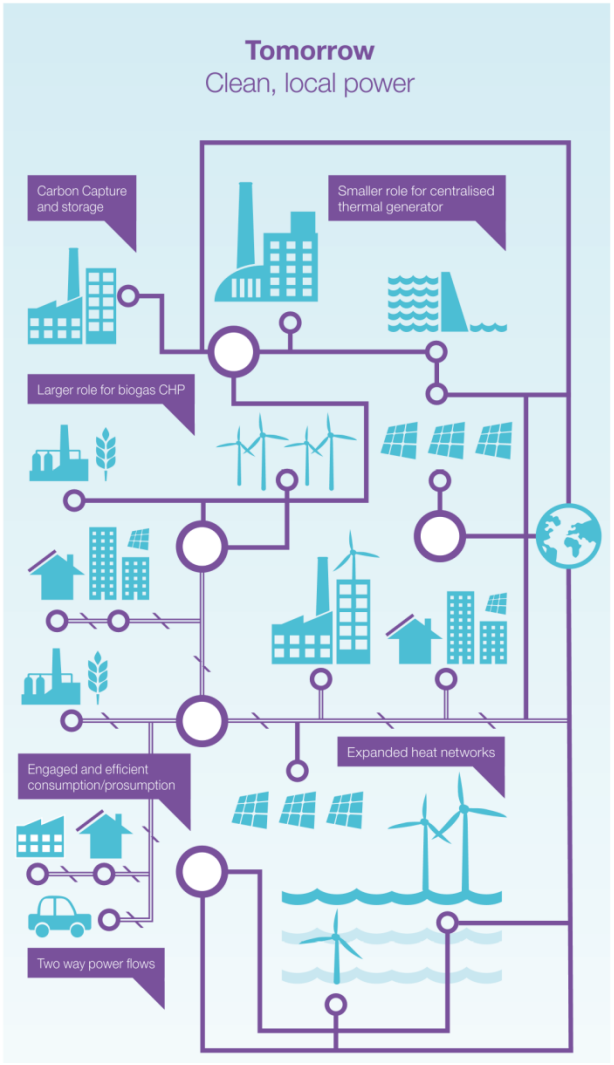
Phase 2: Visioning





- Determine **long-term goals** and objectives through stakeholder involvement
- Clarify **drivers** and consider **project types** that can meet national and regional needs
- Define **desired outcomes** of technology deployment
- Establish a **mission statement** taking into account objectives, national considerations and long-term strategies

Source: What future for cities and the energy system? A UK perspective. Dr. Steve Hall, Univ. Leeds

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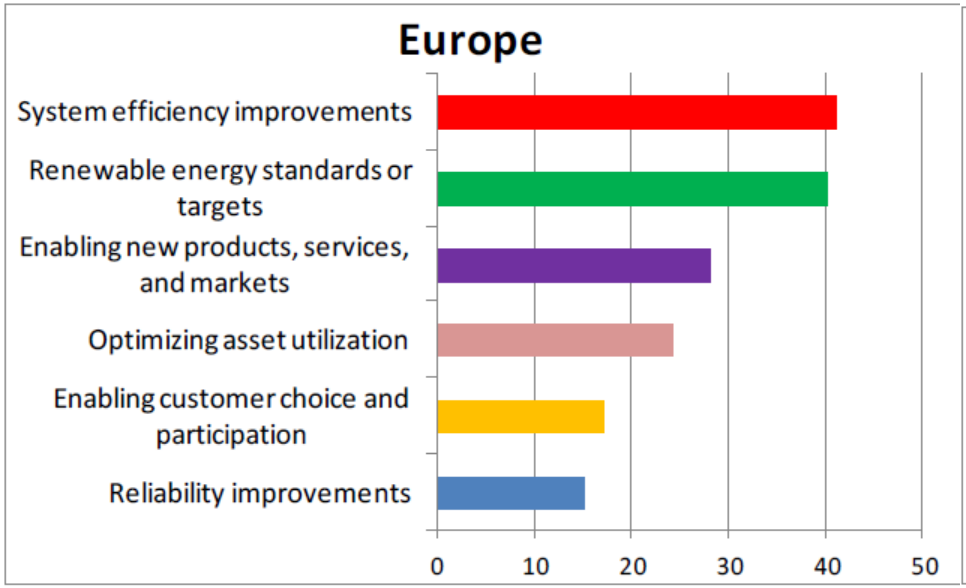
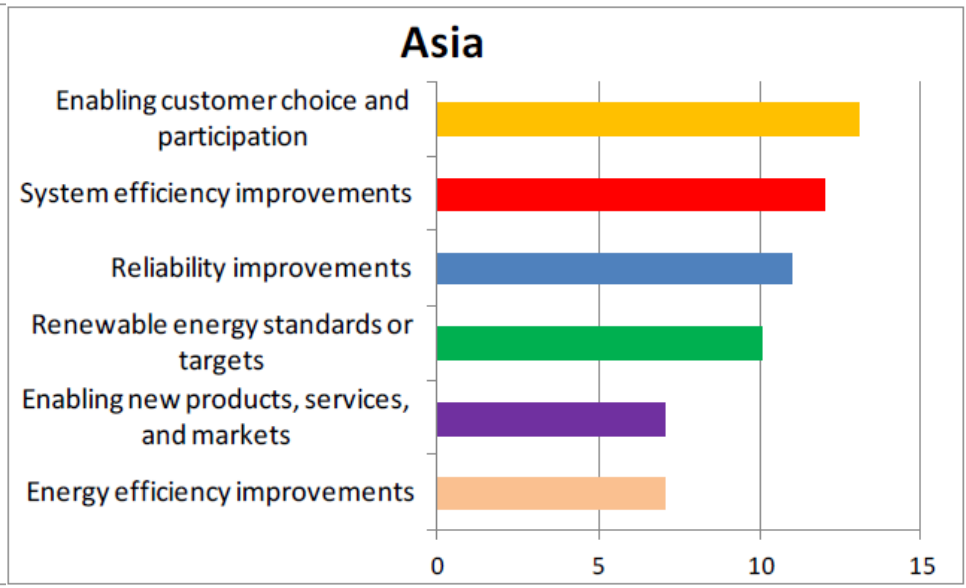
Figure 4 • Top drivers: ISGAN survey analysis of 22 countries





Source: adapted from ISGAN (2014), "Smart grid drivers and technologies by country, economies, and continent," ISGAN website, www.iea-isgan.org/index.php?r=home&c=5/378 (accessed 29 September 2014).

The IEA H2G classifies SG drivers in 7 types

- reliability
- efficiency
- economic
- environmental
- security
- safety
- overall cross-cutting

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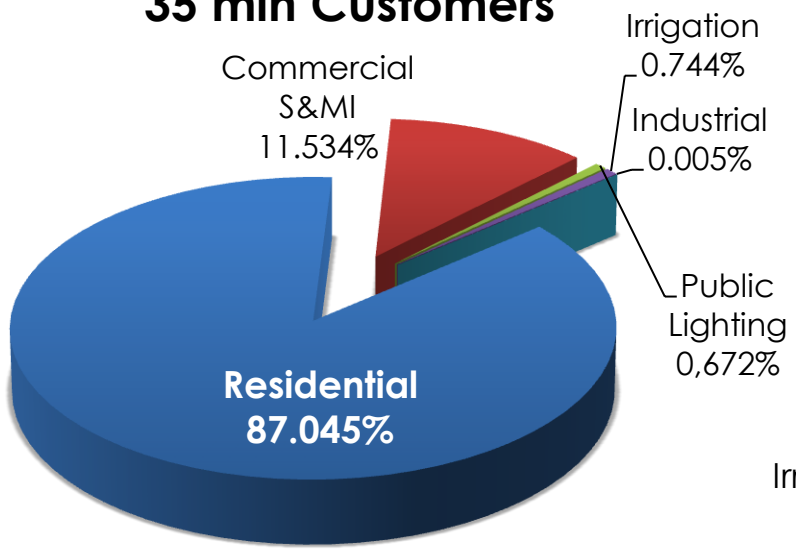
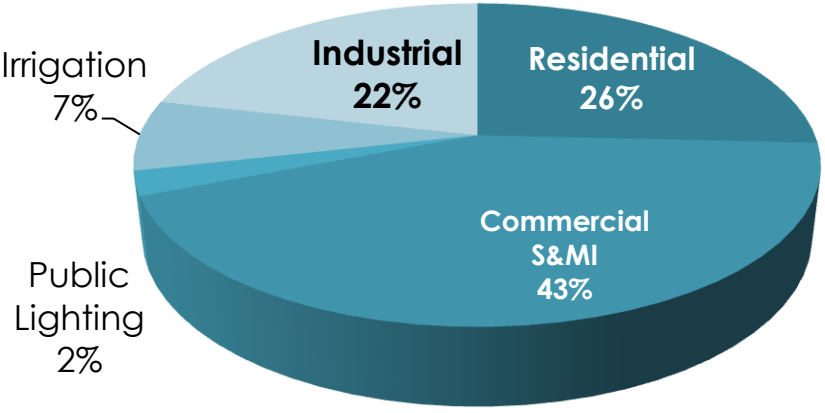
Case study: Mexico (I)

- **Comision Federal de Electricidad (CFE)**: vertically integrated company, with activities in planning, generation, distribution, sales, operations and maintenance

35 mln Customers



ANNUAL SALES 290,9 GWh



Source: CFE, 2015

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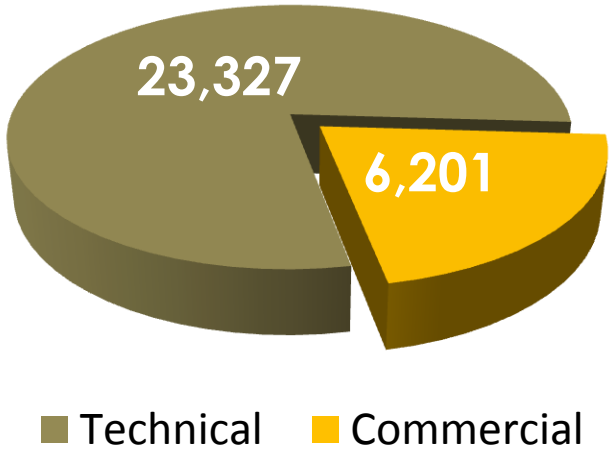
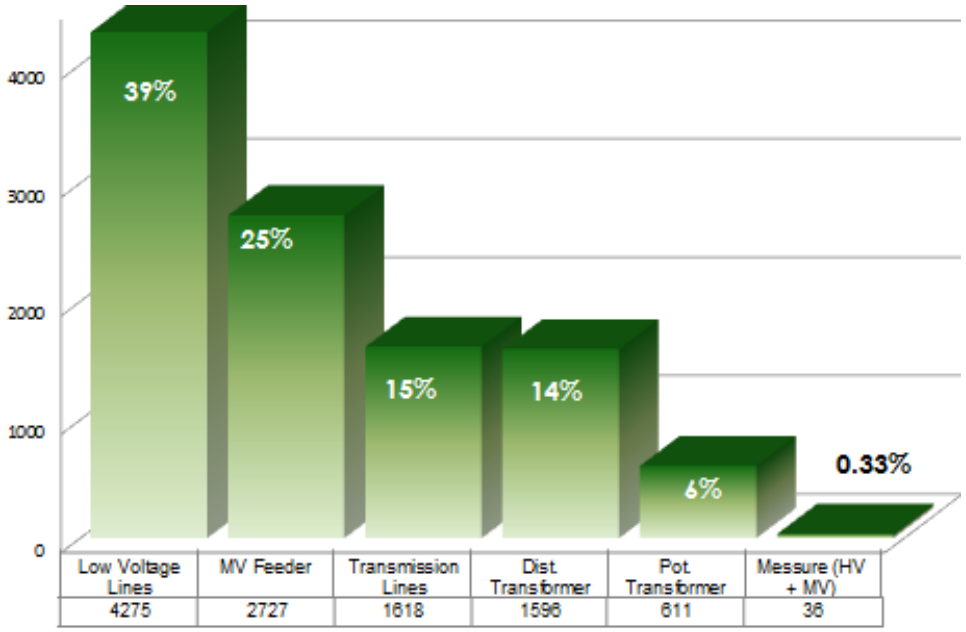
Case study: Mexico (II)

- 79% technical losses and 21% commercial losses or electricity theft = **USD 2,5 million** in decreased revenues (2011)
- Loss reduction as primary driver for 2011-2026 smart grids strategy: installing substations, smart meters and demand management technologies

Source: CFE, 2015

Trasmission and Distribution LOSSES: 29,5 GWh





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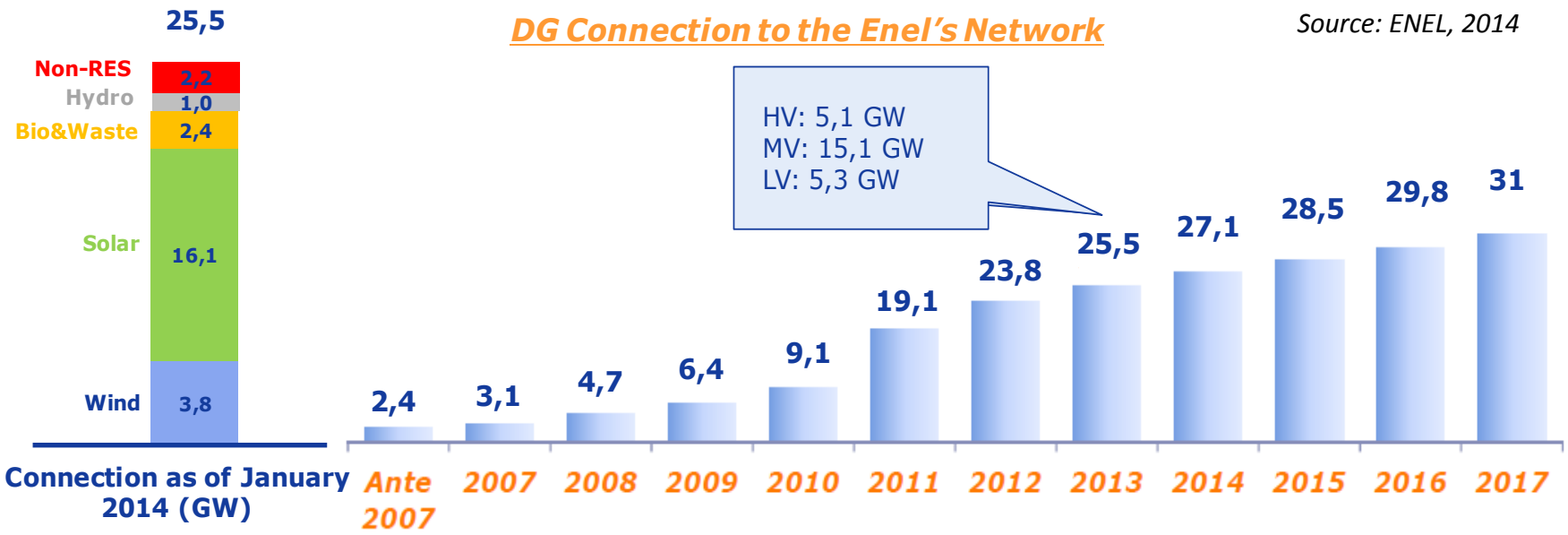
Case study: Italy

The ambitious national support schemes for low-carbon generation led to a **significant market penetration of distributed generation (DG) from RES**



The increased share of RES connected urgently required the evolution of the distribution network management

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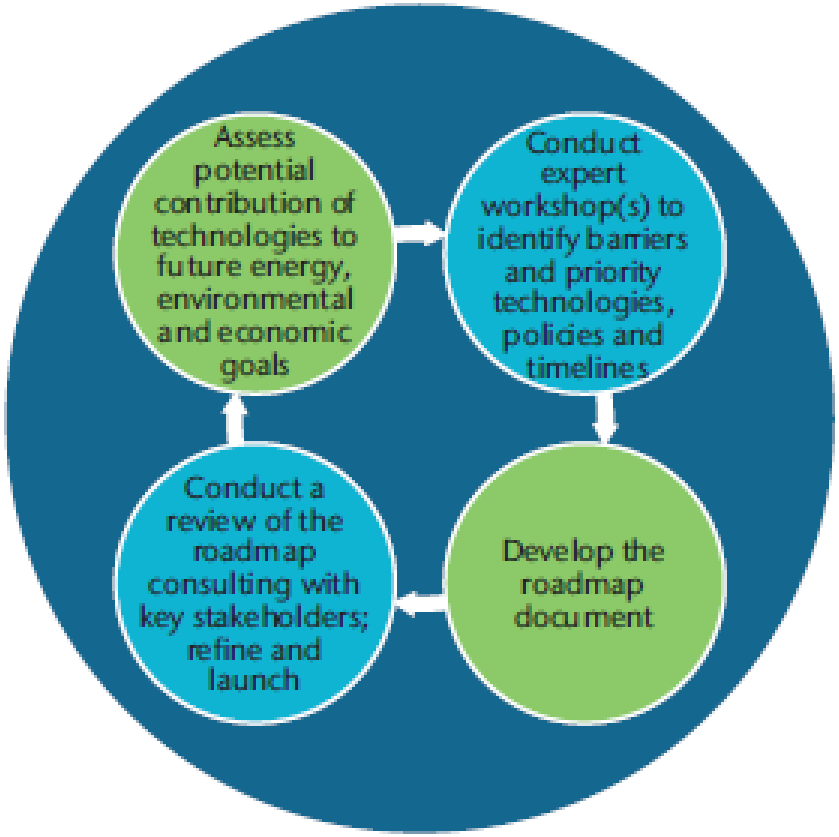
Phase 3: The roadmap document



- Assess the technology deployment in terms of **holistic energy, environmental and economic strategies**
- Identify **potential barriers** and correlated **response actions**
- Determine **priority technologies** that can meet objectives
- Develop a roadmap with stakeholder consultation, setting **timeline and milestones**

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- Advanced Meters (AMI)
- Distribution automation
- Customer-side systems
- DER-Storage
- DER-Distributed generation
- DER-Demand response
- Substation automation
- Asset management

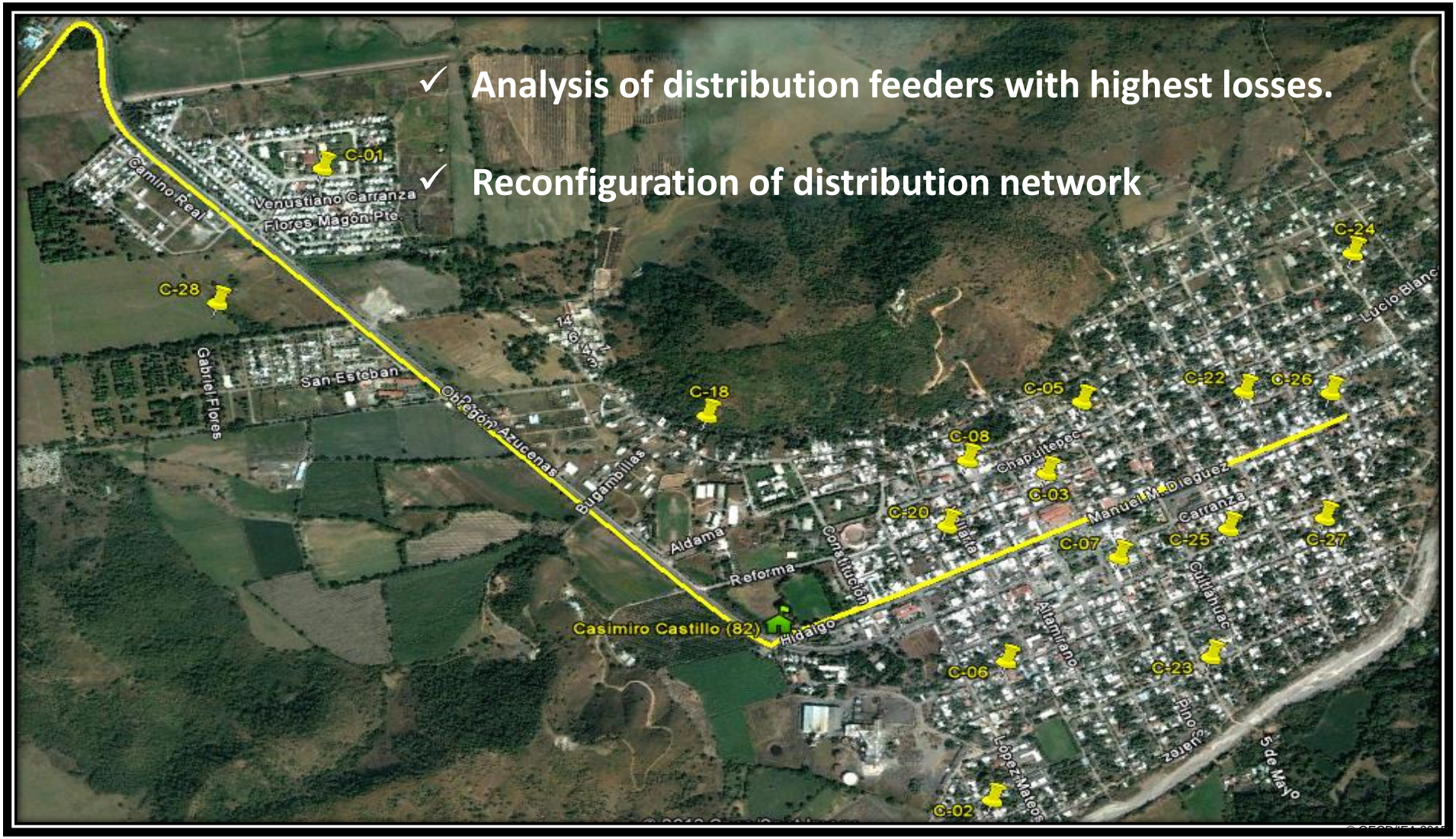
Project type	Advanced Metering Infrastructure	Distribution Automation	Control Center Systems	Customer Side Systems	DER - Storage	DER - Distributed generation	DER - Demand response	Substation Automation	Asset Management
Driver									
Reliability									
Reliability improvements									
Power quality improvements									
Power restoration improvements									
Network adequacy									
Generation adequacy									
Efficiency									
System efficiency improvements (reduction in peak load, T&D losses, etc.)									
Optimizing asset utilization									
Energy efficiency improvements									
Enabling new products, services, and markets									
Enabling customer choice and participation									
Economic									
Economic advantages									
New revenues									
Revenue collection and assurance improvements									
Reducing operating and maintenance costs									
Environmental									
Renewable energy standards or targets									
Reduce carbon footprint									
Regulatory compliance									
Renewables									
Security									
National security concerns									
Enhanced power system resiliency to natural and human threats									
Safety									
Safety improvements									
Crosscutting									
Aging infrastructure concerns									
Rural electrification									
Job creation									
Increased flexibility									
Shifting ownership structures									
Consumer involvement									

Can address driver as a primary outcome of the project	
Can address driver as a secondary outcome of the project	
Can address driver to a small degree as a project outcome	

Case study: Mexico

Source: CFE, 2015

Priority: reduce technical losses



Case study: Italy

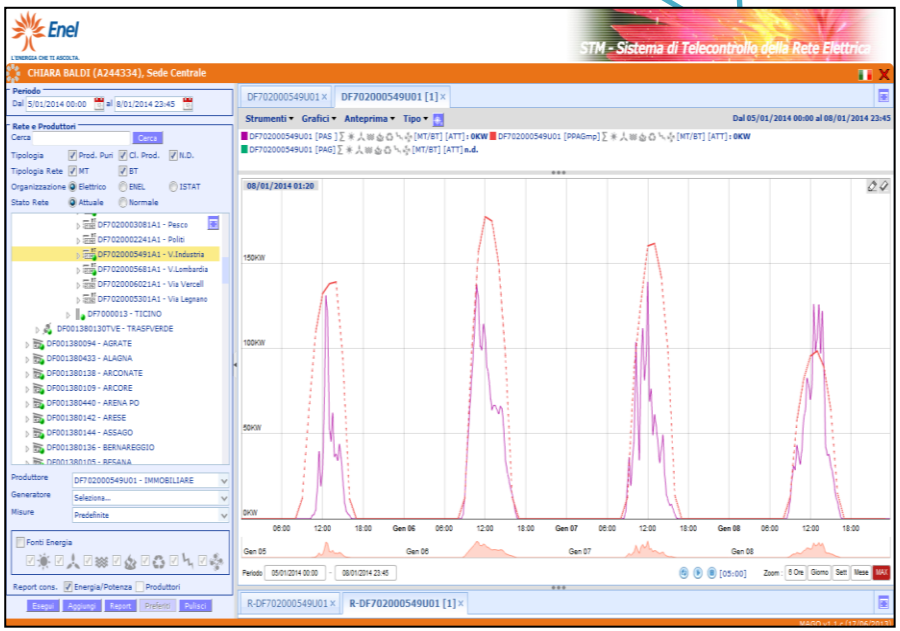
High variable RES

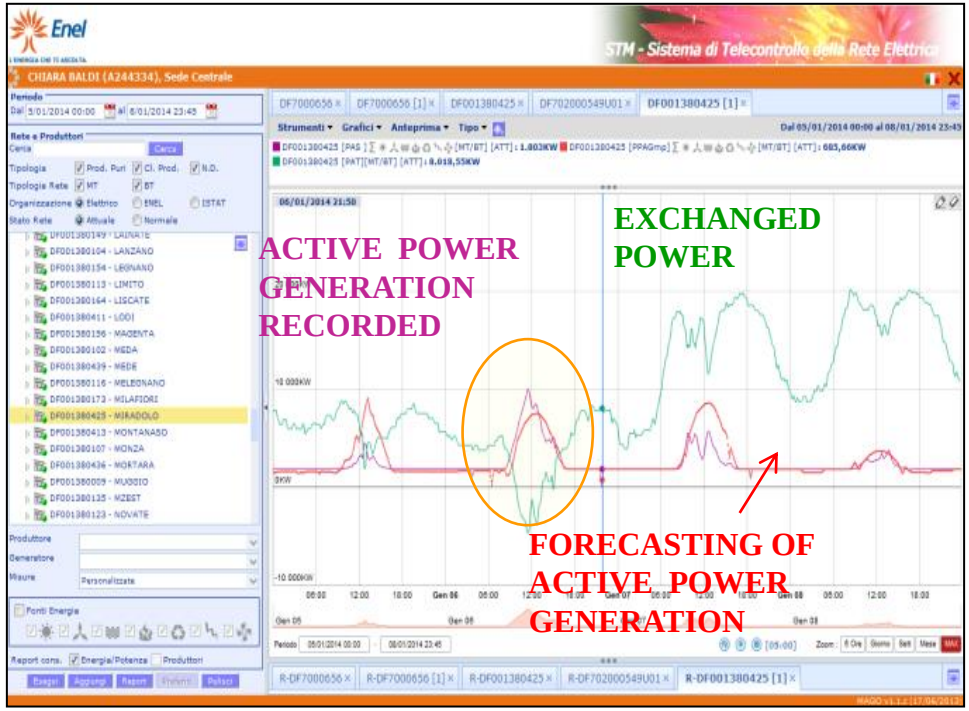
Priority: monitoring and control of active distribution grid operation

Main Features

- Monitoring and Forecasting of Active Power Generation sources connected to the MV and LV feeders;
- Support to Distribution Grid Operators for the daily operation of active network.

POWER GENERATED BY MV PRODUCER COMPARED WITH RECORDED MEASUREMENTS





HV/MV SUBSTATION WITH AN EXAMPLE OF REVERSE FLOW

Source: ENEL, 2014

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Identifying barriers

- **Barriers can be broadly categorised into five areas:**
- legal and regulatory
- project delivery and workforce capability
- economics and financing
- electricity market and systems aspects
- social and cyber security considerations

"We cut through all the red tape, but a new shipment came in this morning."

Barriers and response actions

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	Possible response actions																					
	Legal and regulatory				Project delivery and workforce capability									Economics and financing				Electricity market and systems					Social acceptance and cyber security	
Common barriers	Laws and regulatory strategic planning	Tariff restructuring	Revise ownership structure	Standard product requirement	Targeted installation	Management oversight	Local telecomm partnering	Design to recycle	Develop local workforce	Reskill technicians	Establish new training facilities	Attract qualified workforce from abroad	Adapt higher education curricula	Long-term financing	Private financing	Fiscal incentive schemes	Grants	Progressive installation pace	Support local industry development	Partner with global manufacturer for local production	Develop "open source" products	International partnering	ICT security solutions	Communication campaign
Financing/cost	✓	✓	✓	✓			✓							✓	✓	✓	✓							
Project planning and delivery			✓	✓	✓									✓	✓	✓	✓	✓	✓			✓		
Technical/product solutions				✓				✓												✓	✓			
System operation aspects				✓	✓				✓	✓	✓	✓									✓			✓
Operations and maintenance				✓	✓				✓	✓	✓	✓	✓						✓		✓	✓		
Security/privacy	✓			✓			✓			✓	✓	✓	✓										✓	✓
Legal and regulatory	✓	✓	✓	✓		✓	✓	✓															✓	
Human resources development					✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓		
Cross-cutting	✓		✓			✓									✓	✓					✓		✓	✓

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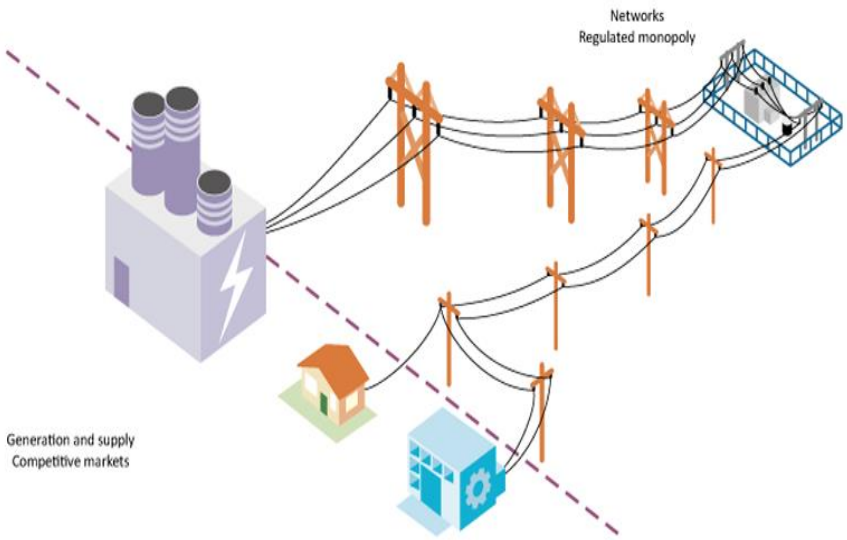
Economics and financing (I)

Under what institutional conditions is smart grid investment more likely or accelerated?



- Revenue structures as opportunity / barrier to smart grid deployment
- Defining and capturing values delivered by the smart grid to assets
- The sum of values must exceed the sum of investments + incentives

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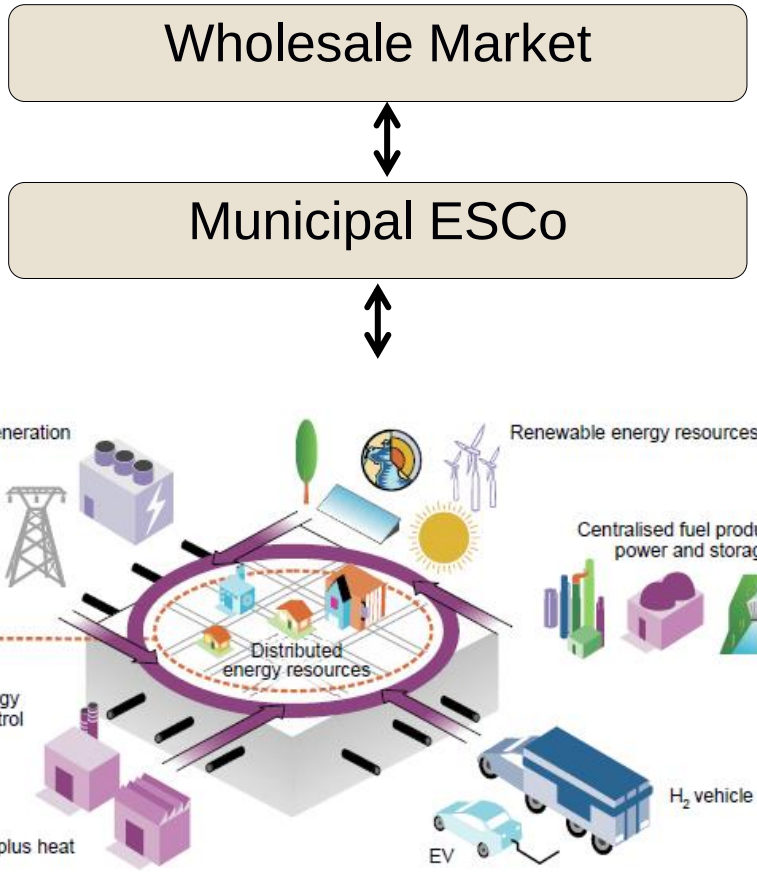
Economics and financing (II)

Example: Municipal ESCos

- Energy services supplier at the city scale
- Enables Local Energy Schemes with PPAs
- Not necessarily grid owner but plays an aggregator role balancing local embedded generation with wholesale purchases



Source: Distributing Power – a transition to a civic energy future Dr. Steve Hall, Univ. Leeds

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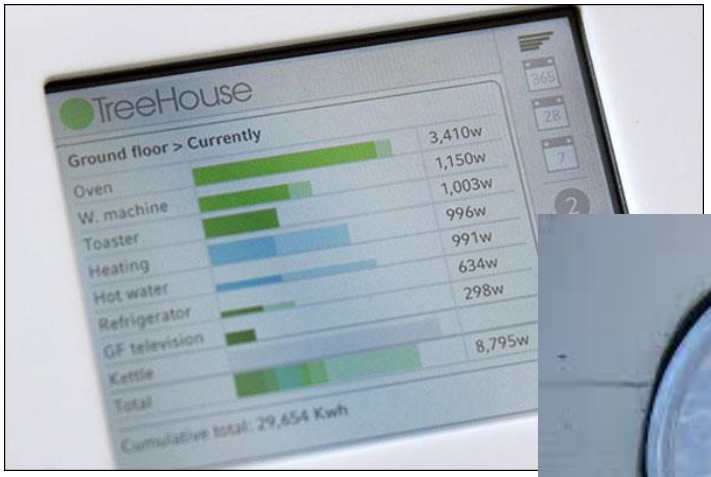
Data ownership and privacy policies



Implement two actions at the outset before the smart meters are deployed:

1) set a privacy policy designed to protect customers and
2) install standard and advanced cyber security technologies

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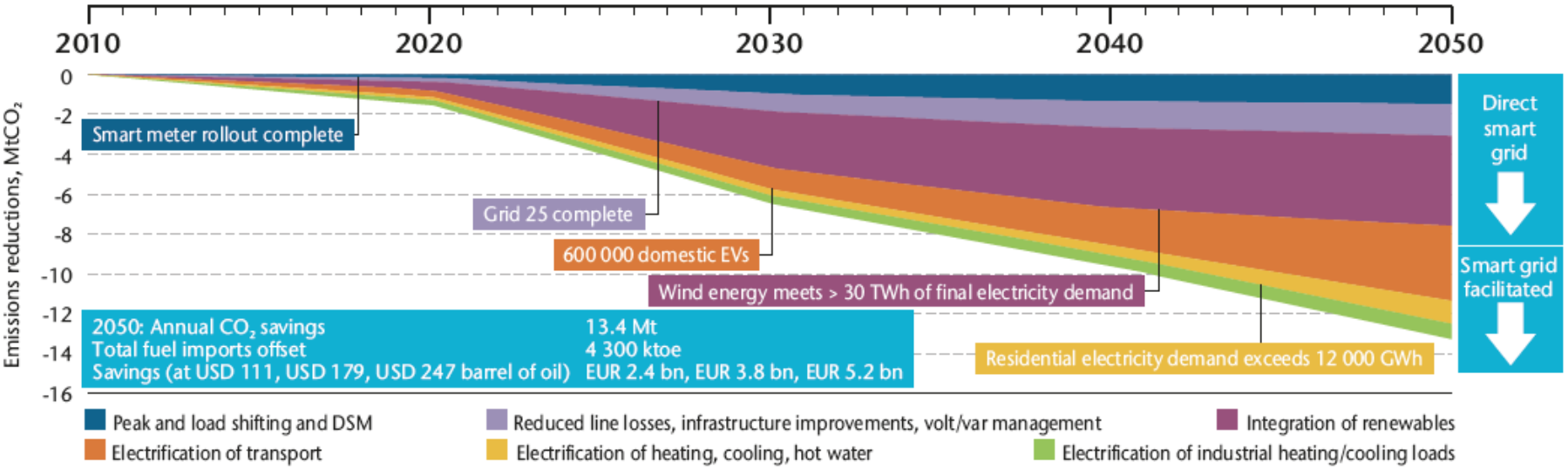
Phase 4: Implementation, monitoring and revision

Figure 13: Irish smart grid roadmap: Key milestones



Source: SEAI, Ireland

- Strategic roll-out of selected technologies
- Develop a monitoring system with quantitative and qualitative indicators measuring success of implementation
- Track changes in other related sectors that influence roadmap implementation
- Re-evaluate and re-assess priorities, timelines and objectives; update the roadmap as necessary

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China's energy challenge

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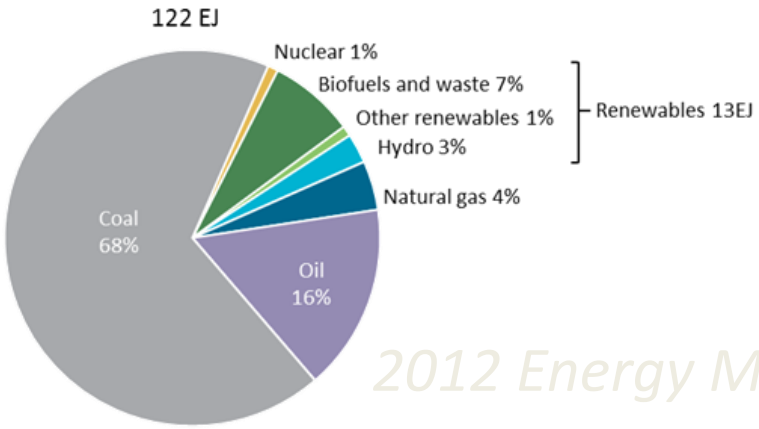
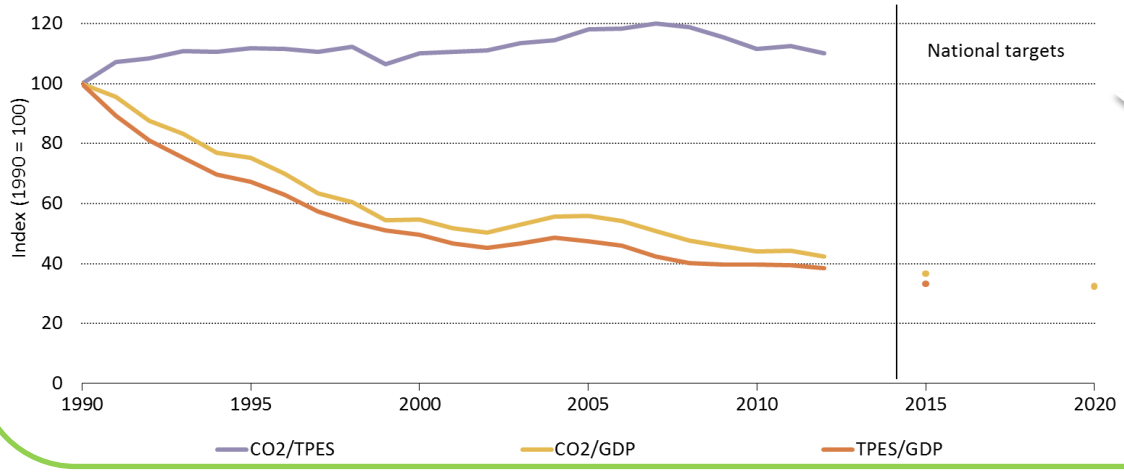


2012 Energy Mix

2030 Target

Non-fossil sources to provide 20% of primary energy mix

Carbon intensity trends



40 to 45% CO_2 emissions reduction per unit of GDP compared to 2005

2020 Target

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Monitoring progress

Indicator type	Description	Metrics
Smart grid technology deployment	• Number of (pilot) projects implemented • Generation capacity connected to the smart grid • Reduction of losses • Consumer adoption of technologies	• Units • MW/GW • Comparison with pre-smart grid metrics • Number of consumers connected to the smart grid
Financial	• Grants and incentives available • Market expansion for smart grid technologies • Project financing with lending by financial institutions	• Total value of secured funds • Monetary growth over timeframe • USD
Processes	• Number of stakeholder workshops organised • Number of new institutions created • Effectiveness of awareness raising/campaigns organised	• Unit • Unit • Number of customers impacted by marketing or engagement strategies; qualitative assessment of customer acceptance
Policy	• Policies defined and adopted • Increase in political support • Milestones specific to sectoral strategies	• Unit; qualitative assessment of goals of policies and whether the right tools are being deployed • Qualitative assessment of policy makers' actions • Number of milestones being met
Socio-economic and environmental impact	• Social: jobs created; customer education/training • Environmental: CO_2 reductions; increased system efficiency	• Number of jobs and customers reached • Comparison with pre-smart grid metrics

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International collaboration and knowledge transfer

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- Tracking and monitoring progress can be challenging
- Collaboration with the **IEA, ISGAN** and other int. organisations and networks to exchange experiences on:
  - **existing barriers or issues** to technology deployment
  - engaging **relevant stakeholders** on policy and investment opportunities
  - identifying **response actions** that foster next steps towards energy innovation in China

IEA – SENER - FSE: 29 May 2015, Mexico City

- **Key challenge:** co-ordination among regulatory, electricity, and grid authorities
- **Key opportunities:** Mexico's 2014 energy reform presents a strong focus on opening the market for new players and management strategies; huge potential for increased renewable energy and flexibility with use of smart grid technologies

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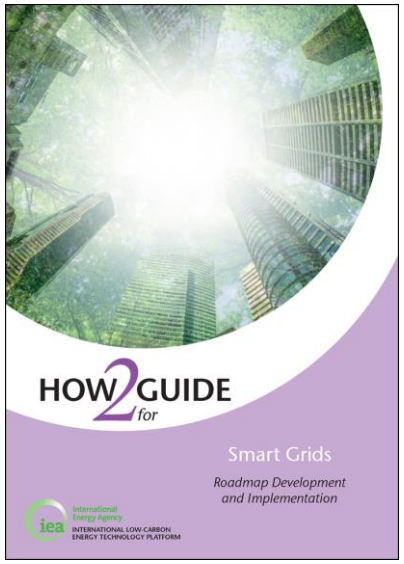
Closing remarks…

- ***How2Guide for Smart Grids in Distribution Networks*:**
  - Step-by-step framework for roadmap development and implementation
  - Engage diverse stakeholders throughout all phases of planning and implementation
  - One size does not fit all. Take national/regional drivers into full account to identify the smart grid technology options that respond best to local needs
  - Monitor, re-evaluate and revise the roadmap—it is not a document to be “left on the shelf”!



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…and take-away messages

- **The overarching message on smart grids is twofold:**
  - (I) Smart grids are advanced technologies to **improve overall system efficiency** and options, including greater integration of **renewable energy**.
  - (II) Smart grids can be an infrastructural catalyst for enabling **energy sector transformation**, including supporting **sustainable urban development**.

- **Recommendations:**
  - (1) **Multilevel governance is critical**. National and local energy system policy, strategy and system regulation cannot be treated in isolation.
  - (2) **Get the demand side right**. Demand and supply should be integrated at the city scale so energy policy needs to treat distributed generation and (aggregated) demand response equally and in the same framework.
  - (3) **New stakeholders mean new business models**. New ways of valuing energy systems are needed that require new decision support tools.

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Thank you!

- *How2Guide for Smart Grids in Distribution Networks:* http://www.iea.org/publications/freepublications/publication/technology-roadmap-how2guide-for-smart-grids-in-distribution-networks.html
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