Redes eléctricas inteligentes
Introducción

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   - Agentes
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   - Beneficios
4. **¿Cómo conseguirlo?**
   - Roadmaps
   - Iniciativas y proyectos

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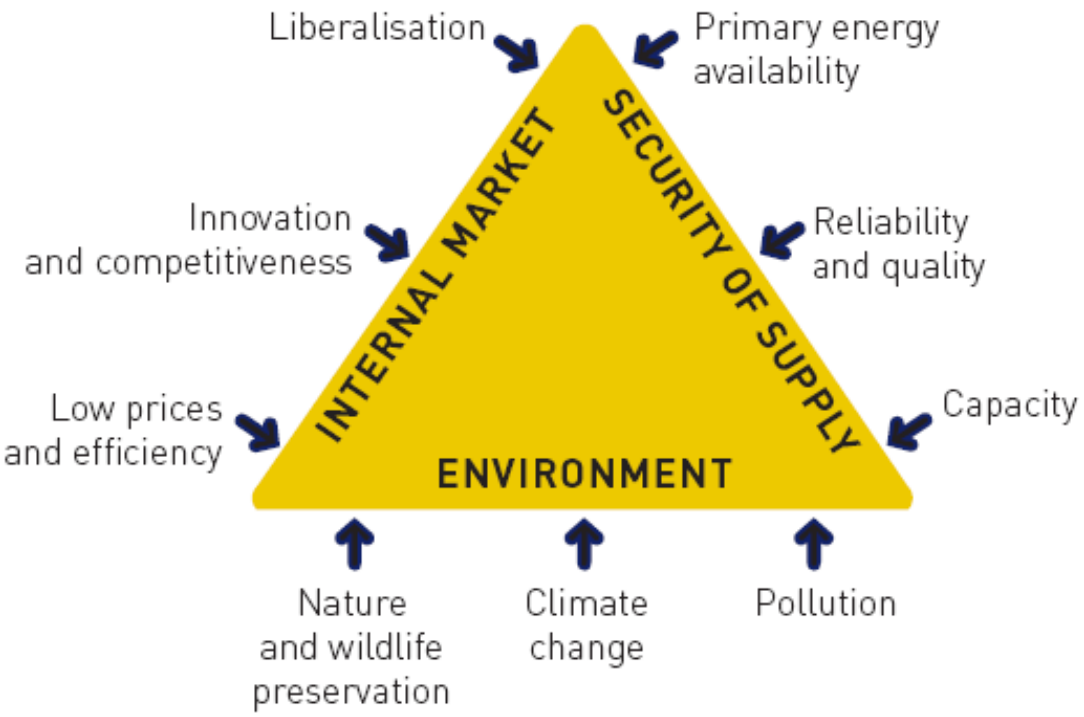
¿Qué son?

Política energética europea

- Promoción de energías renovables (RES) y cogeneración (CHP)
- Aumento de la eficiencia energética
- Reducción de emisiones de CO2
- Aumento seguridad suministro



¿Cuál es la definición de redes inteligentes ?

- No hay una única definición
- EU Smart Grids Technology Platform: "*electricity networks that can **intelligently** integrate the actions of all users connected to it –generators, consumers and those that do both- in order to **efficiently** deliver sustainable, economic and secure electricity supplies*" (www.smartgrids.eu)
- ¿Inteligencia en qué?
  - Nuevas tecnologías y soluciones: comunicaciones, datos, control,…
  - Mejor uso y planificación de instalaciones existentes
  - Control masivo inteligente y distribuido de generadores y cargas
  - Nuevos servicios y mejoras en eficiencia energética
- Concepción amplia:

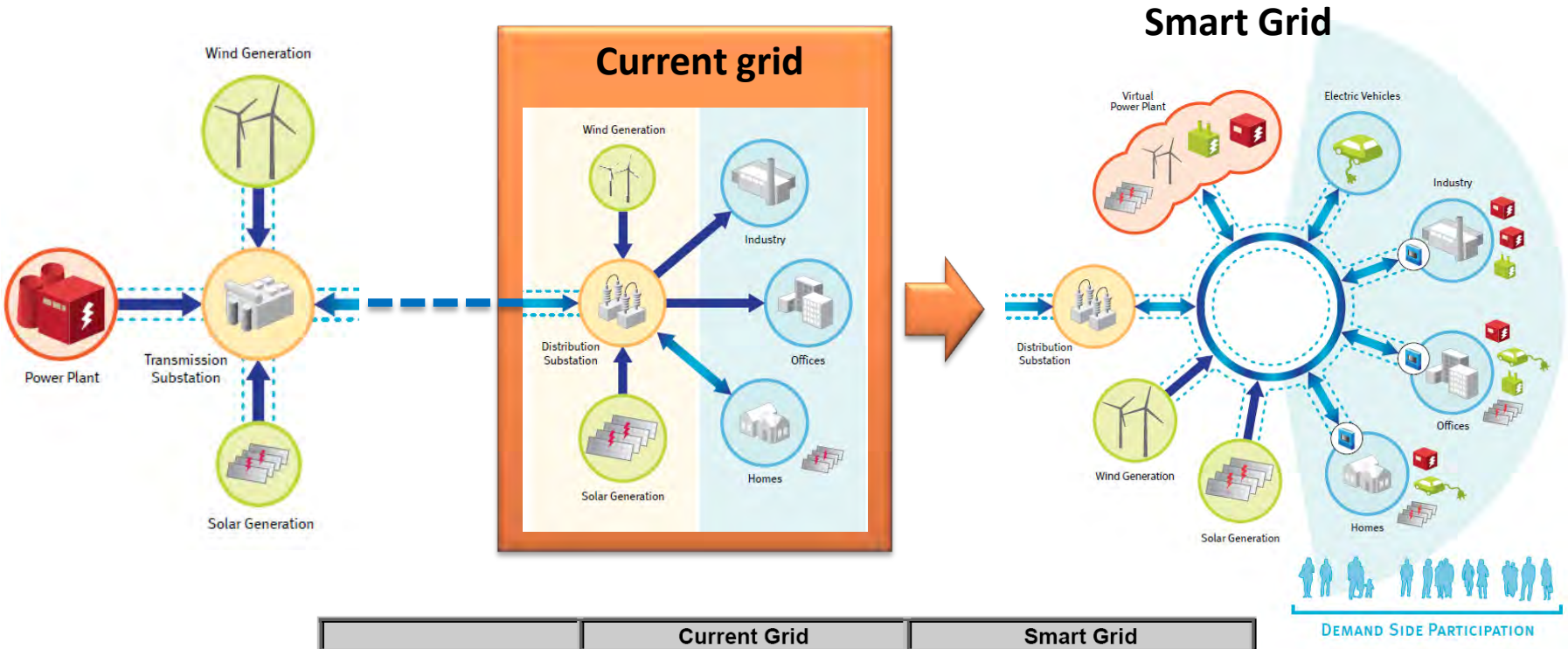
  "*SG are about building, expanding, operating and maintaining the electricity networks of the future to meet the 20/20/20 energy policy objectives*"

Estructura y operación de redes: situación actual

Network		Infrastruc-ture	Typical operation	N. of users	N. of installa-tions	Operation flexibility	Monitoring degree
Transmission (Security of supply) (400, 275, 220kV)		Meshed	Meshed	Very few	Few	High	High
Distribution (Quality of supply)	Distribution (132, 45, 66kV)	Meshed	Meshed / Radial	Few	Many	Average	High
	Medium voltage (20, 15kV)	Meshed/ Radial	Radial	Many	Many	**Poor**	**Average**
	Low voltage (400, 380V)	Meshed / Radial	Radial	**A lot**	**A lot**	**Very poor**	**Low**

("Control tensión - reactiva en la red de distribución de Unión Fenosa", Beceiro & D. Trebolle, 2008)

Arquitectura



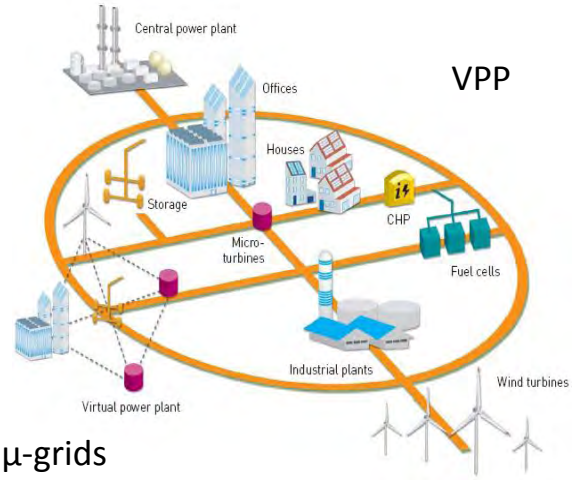
	Current Grid	Smart Grid
Communications	None or One-way	Two-way
Customer Interaction	Limited	Major
Meter Type	Electromechanical	Digital
O&M	Manual equipment checks	Remote monitoring
Power Supply Support	Centralized Generation	Centralized and Distributed Generation
Power Flow Control	Limited	Pervasive
Reliability	Prone to failures and blackouts	Adaptive protection and islanding
Restoration	Manual	Self-healing
Topology	Radial	Network

(Research Report International, 2007)

Tecnologías y componentes

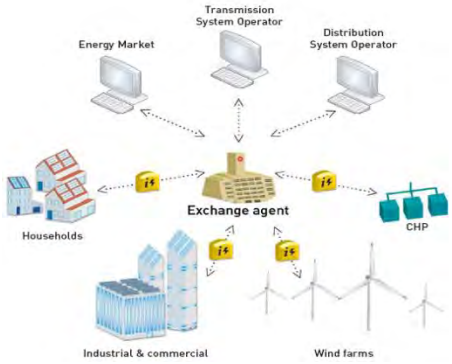
- Tecnologías:
  - Infraestructura de comunicaciones
  - Medida y supervisión
  - Control avanzado
  - Interfaz con operadores y usuarios
- Componentes:
  - Normalización
  - Generación distribuida
  - Calidad de servicio
  - Medidores inteligentes
  - Gestor energía (energy box)
  - Virtual Power Plants (VPP) y micro-grids
  - Agregadores de productos y servicios

VPP



µ-grids

Market aggregator



Agentes involucrados

- **Consumidores finales**
  - Demandan mejores precios y calidad (en ciertos segmentos)
- **Operadores de redes: transporte y distribución**
  - Requieren invertir en nuevas tecnologías y soluciones
  - Necesitan marco regulatorio claro y estable
- **Comercializadores y empresas de servicios energéticos**
  - Podrán ofrecer nuevos servicios: gestión energía, eficiencia, precios a medida del usuario
- **Promotores de generación especial: renovable y CHP**
  - Integración eficiente y segura de su producción proporcionando nuevos servicios
- **Fabricantes de equipos**
  - Nuevas tecnologías y oportunidades de negocio
- **Reguladores**
  - Negocios regulados de redes: incentivar inversión y eficiencia
  - Negocios en competencia: eliminar barreras de entrada

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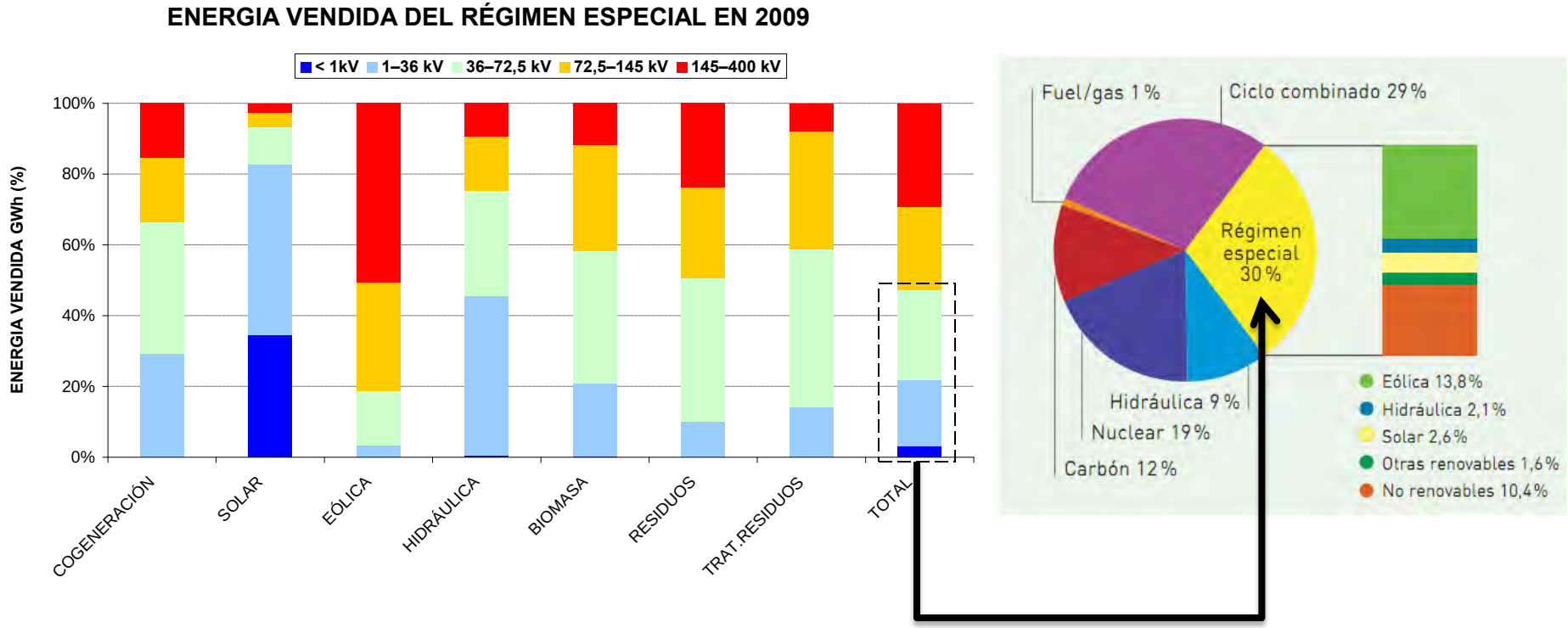
¿Por qué son necesarias?

DG, RES, EV and DMS

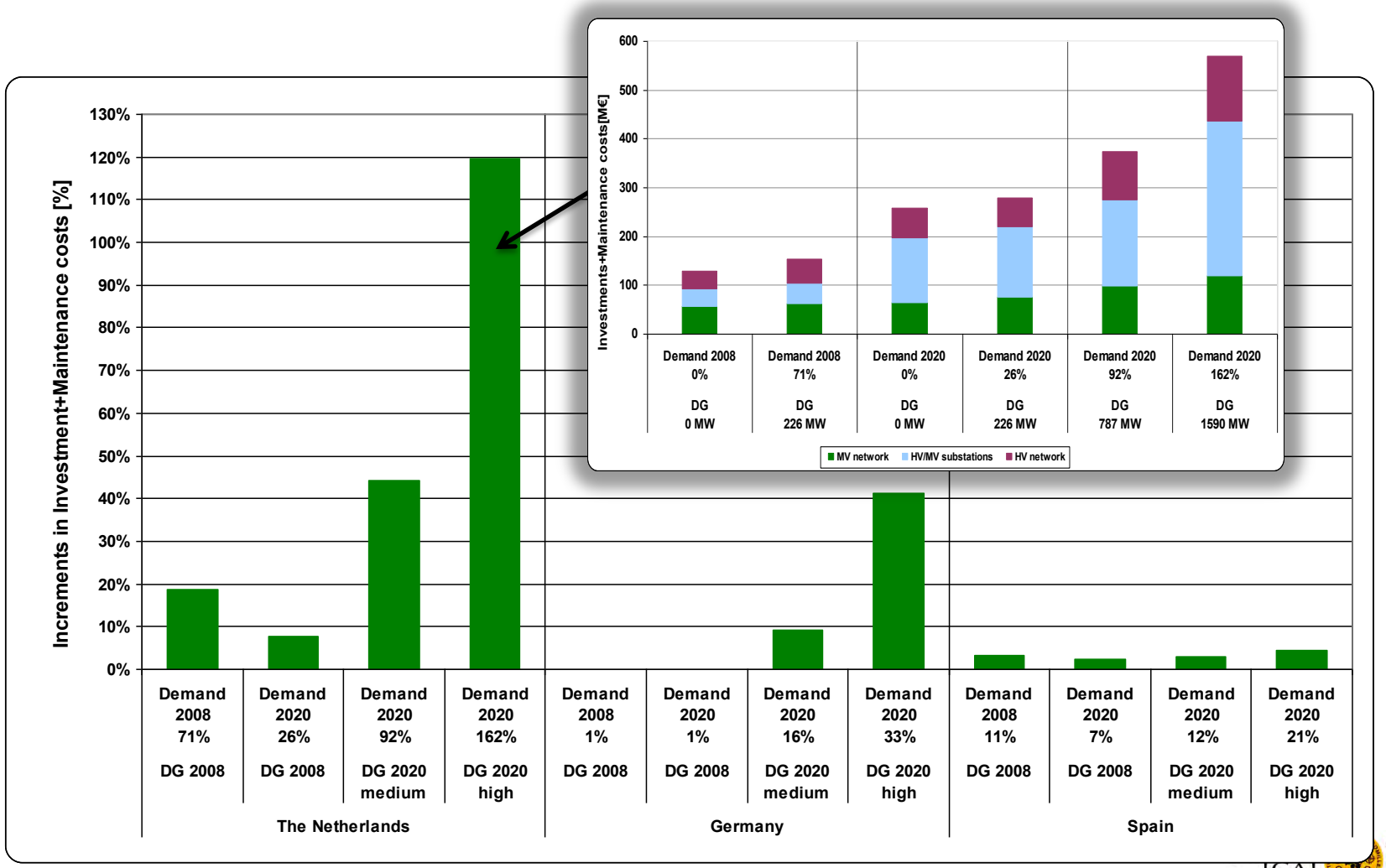
Generación distribuida

- "Generación distribuida" es la que se conecta en las redes de distribución o en las instalaciones de los consumidores (European Directive 2009/72/CE).



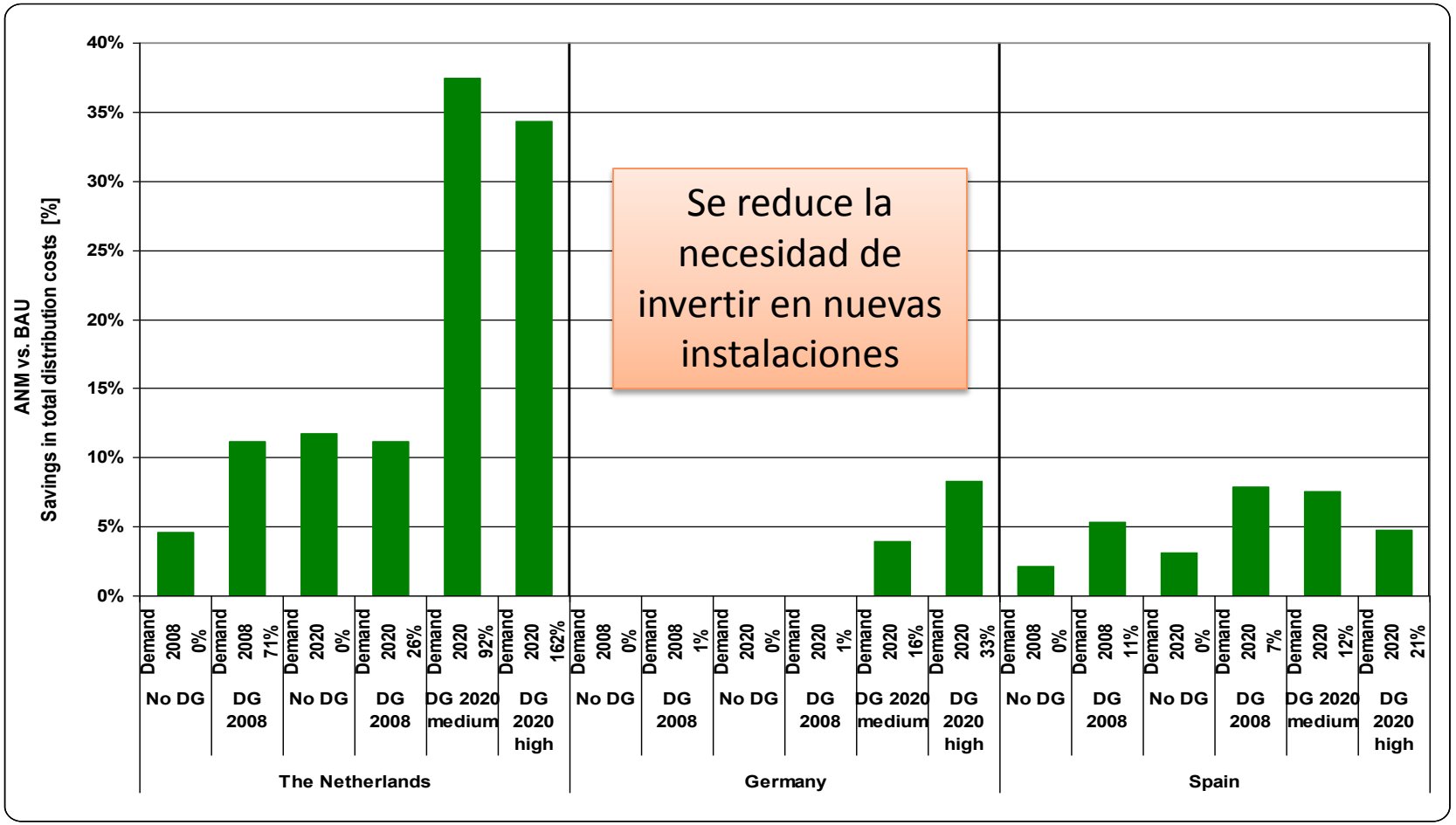
Generación distribuida: planificación red

- **Problema**: Impacto en las inversiones en red del distribuidor



Generación distribuida: planificación redes

- Ahorros en inversiones de red considerando redes inteligentes



Generación distribuida: regulación

- ¿Cómo hay que regular para integrar eficientemente a la GD?
  - Problemas y soluciones para los distribuidores (DSOs)
  - Problemas y soluciones para los operadores de GD

Regulation needs

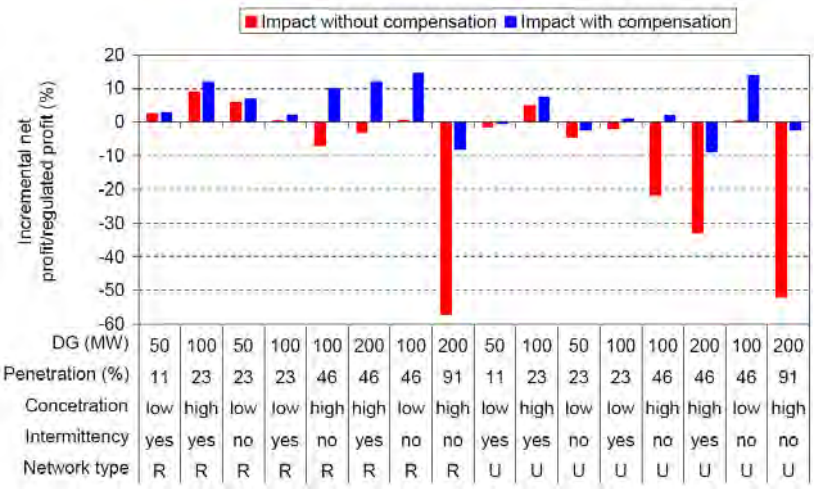
… for the DSO:

- Incremental CAPEX & OPEX included in remuneration scheme (system reinforcements, losses, smart-meters, …)
- Integrate DG in network planning
- DG can help to improve DSO quality of service. Incentive for innovation programs.
- DSO must become a “local system operator” rather than a “distributor”
- Need of grid-codes for distribution

… for DG owners/operators:

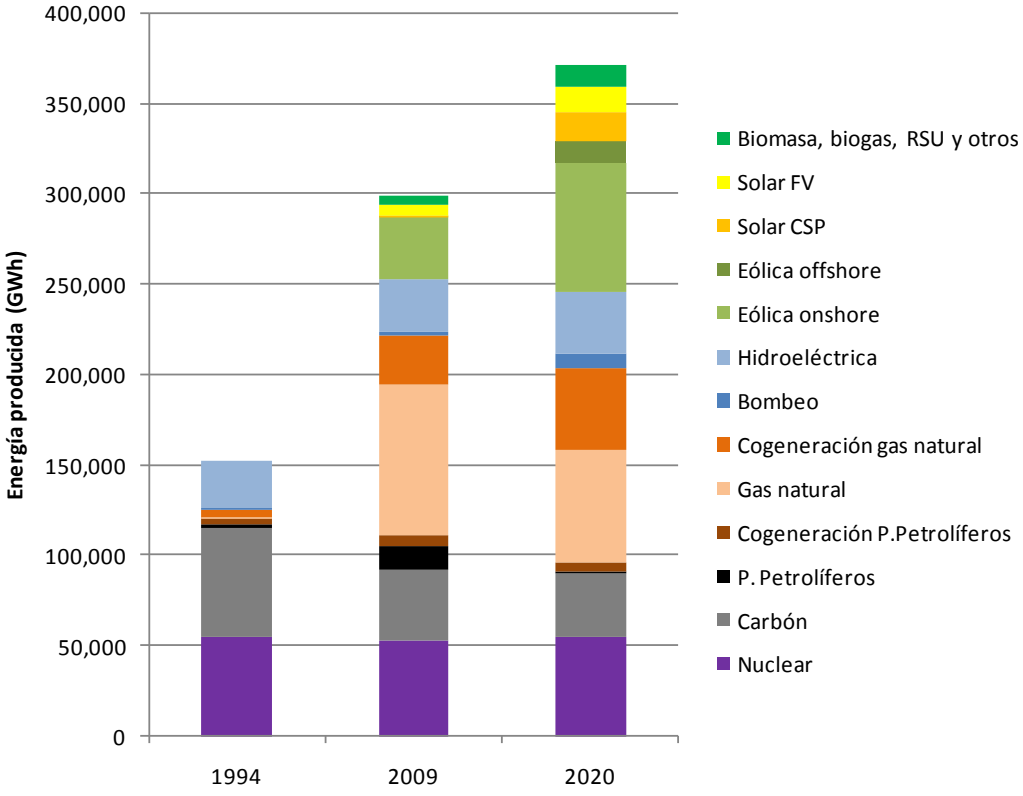
- Avoid flat feed-in tariffs, ToU tariffs
- Incentives to participate in network operation

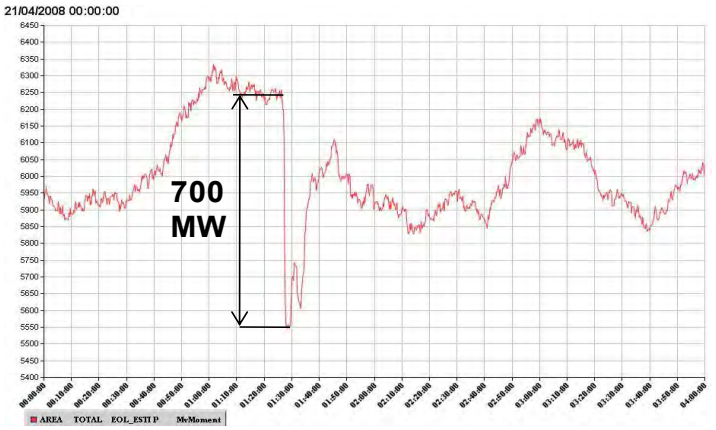
$$R_t = R_{t-1} \times (1 - X) + \gamma_1 \cdot kW^{DG} + \gamma_2 \cdot MWh^{DG}$$

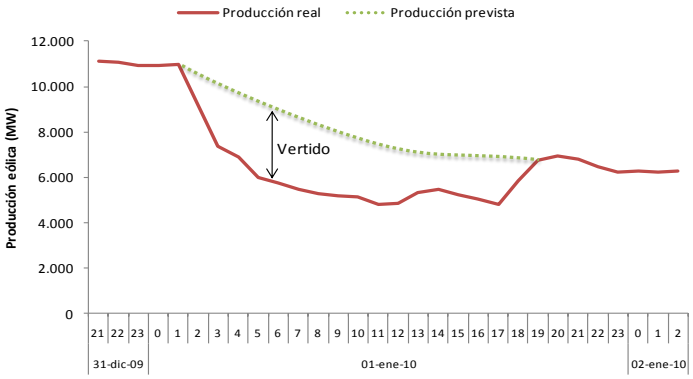


Integración de renovables en la operación

- En el futuro la penetración de renovables seguirá creciendo
- Cambio en el mix de generación
- Retos para integrar la energía variable y de difícil predicción (eólica y solar)



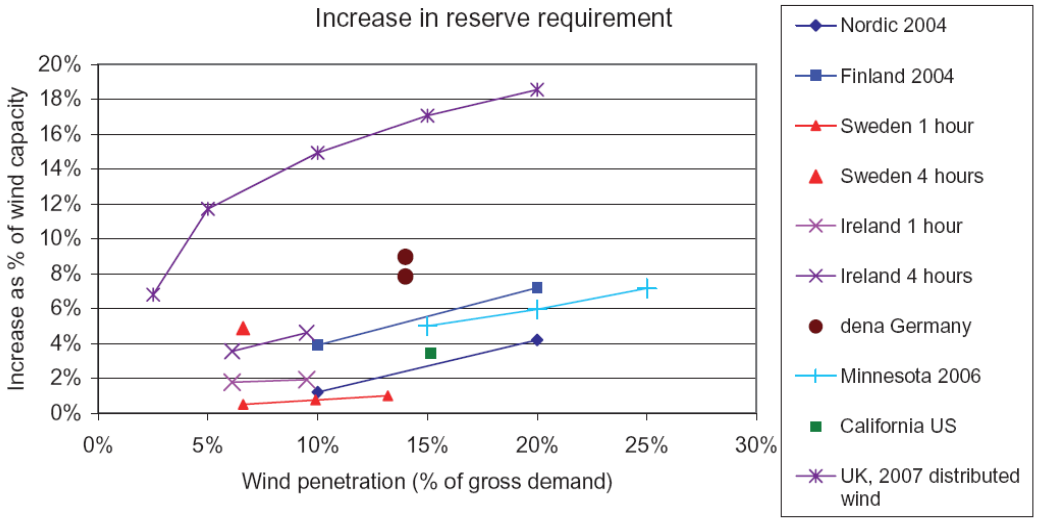




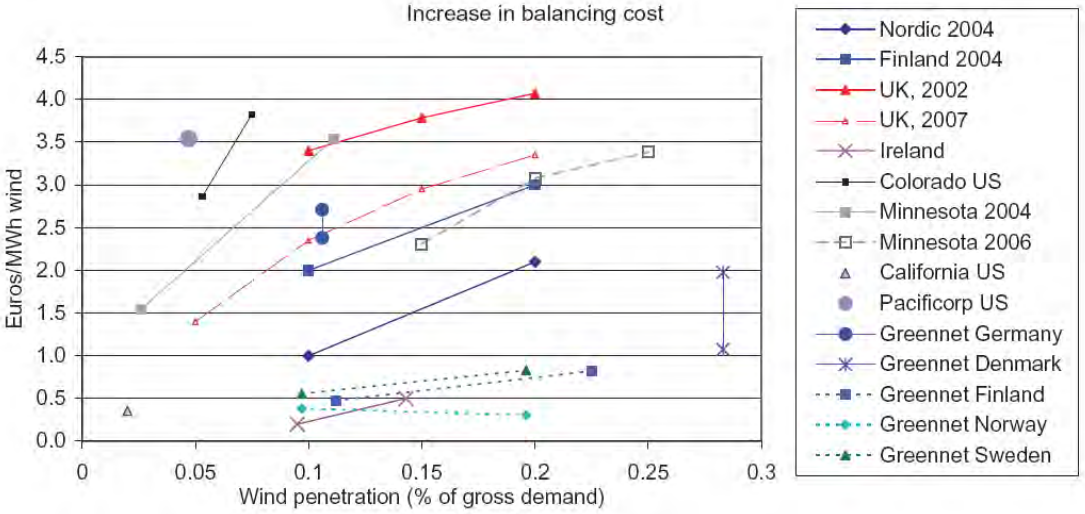
Impacto en la operación de la red

(Holttinen, 2010)

- Necesidad de capacidad de reserva adicional



- Costes adicionales



Integración de renovables

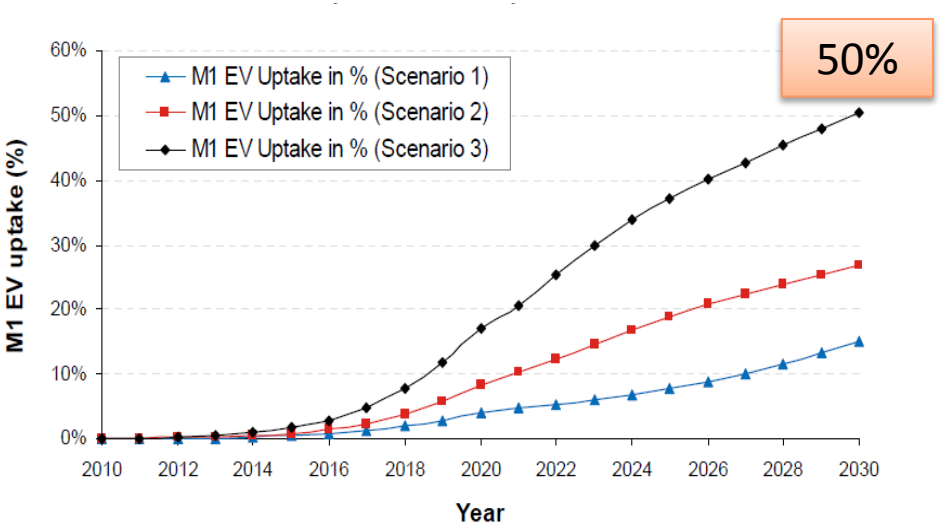
- ¿Qué necesitamos cambiar o mejorar para la integración segura y eficiente de la producción renovable?

Technical & Regulation needs

- Technical requirements for RES (e.g. voltage dips)
- RES Control Centers (CECRE, CORE, …)
- Forecasting tools improvement
- Interconnection capacity increase (SP-FR)
- Pumping and other storage technologies contribution
- RES participation in power system AASS
- More flexibility and back-up from conventional power plants (gas and coal)

Vehículos eléctricos

- La penetración masiva de esta tecnología se espera en Europa en la década 2020/2030
- Beneficios de una carga inteligente



VEHICLE CLASS	DESCRIPTION	
L7e	Quadricycle - Four wheels, with a maximum unladen mass of 400kg or 550kg for a goods carrying vehicle (not including the mass of the batteries in an electrically powered vehicle) and a maximum net power, whatever the type of engine or motor, of 15kW	
M1	Passenger vehicle, four wheels and up to 8 seats in addition to the driver's seat.	
N1	Goods-carrying vehicle, four wheels, with a maximum laden mass of 3500kg.	
N2	Goods-carrying vehicle, four wheels, with a maximum laden mass between 3,500kg and 12,000kg.	

Table 5: Vehicle classes [5]

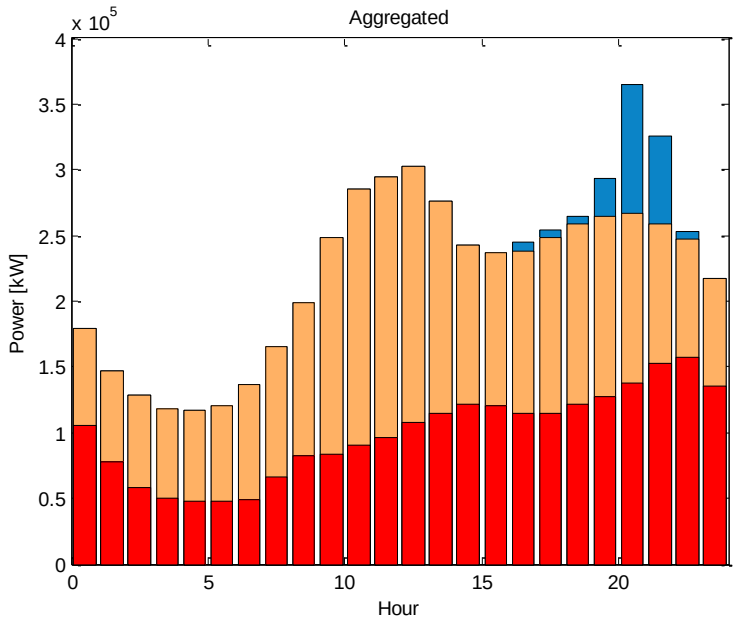
Type		Standard Battery Charging Rates (kW)			Fast Charge Rate* (kW)
		Mode	Min	Max	Range
L7e	BEV	3	1	3	3-7.5
M1	BEV	3	2	9	3-240
	PHEV	3	3	5	11
	EREV	3	3	5	-
N1	BEV	3	1	3	10-45
	PHEV	3	3	3	11
	EREV	3	3	5	-
N2	BEV	10	-	-	35-60

Table 19: Summary table of battery charging rates for use in model. (*Maximum value of fast charge rate may exceed charging point capabilities, so maximum values if used in modelling should be used with caution)

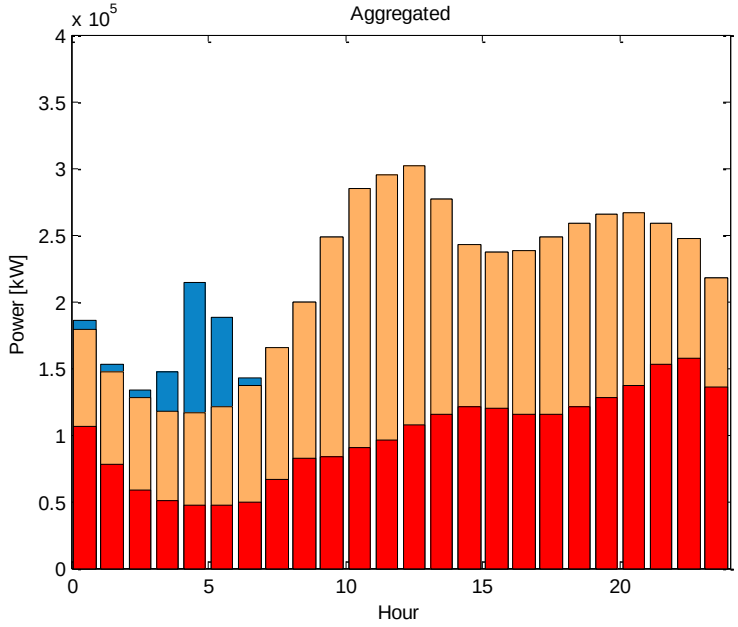
Vehículos eléctricos: impacto en la red

- Simulación: Area con 170.000 consumidores y 31.200 EVs

Dumb charging at peak hours



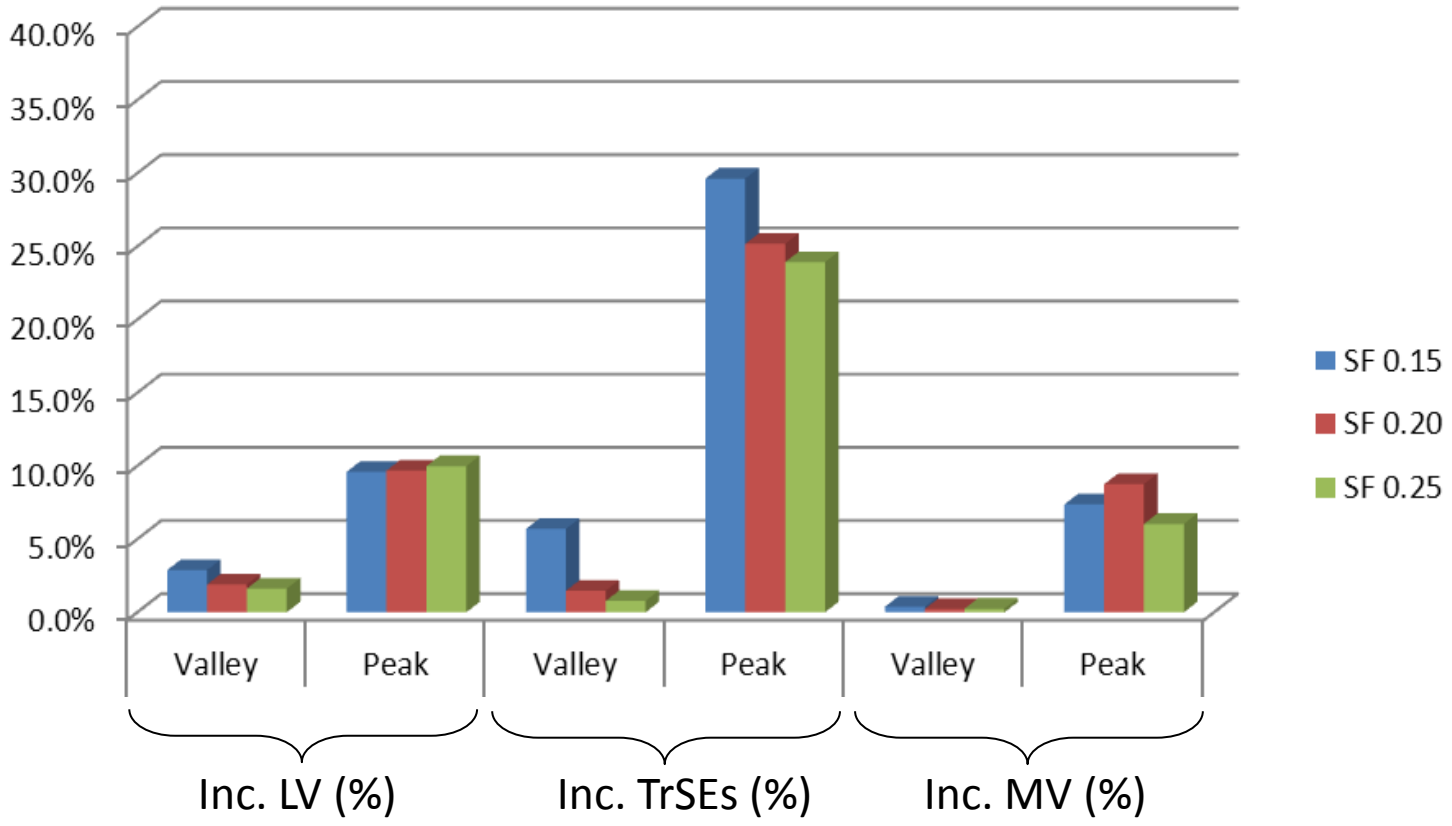
Smart charging at valley hours



EV charge
Industrial load
Domestic load

Vehículos eléctricos: impacto en la red

- Necesidad de inversiones en refuerzos de red disminuyen con estrategias de carga inteligente



Vehículos eléctricos: regulación y estandarización

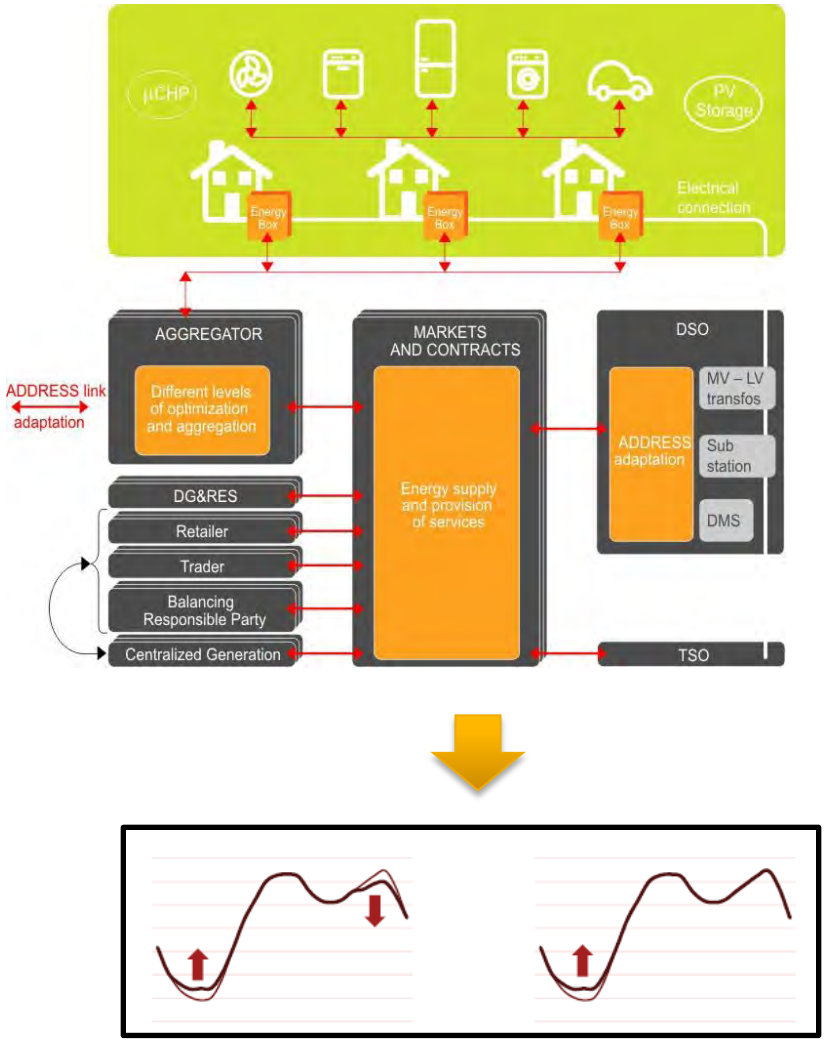
- Si nos compramos un vehículo eléctrico:
  - ¿Dónde lo cargaremos?
  - ¿Cuanto pagaremos por la recarga?
  - ¿Qué beneficios recibiremos por realizar una recarga inteligente ?

Regulation needs

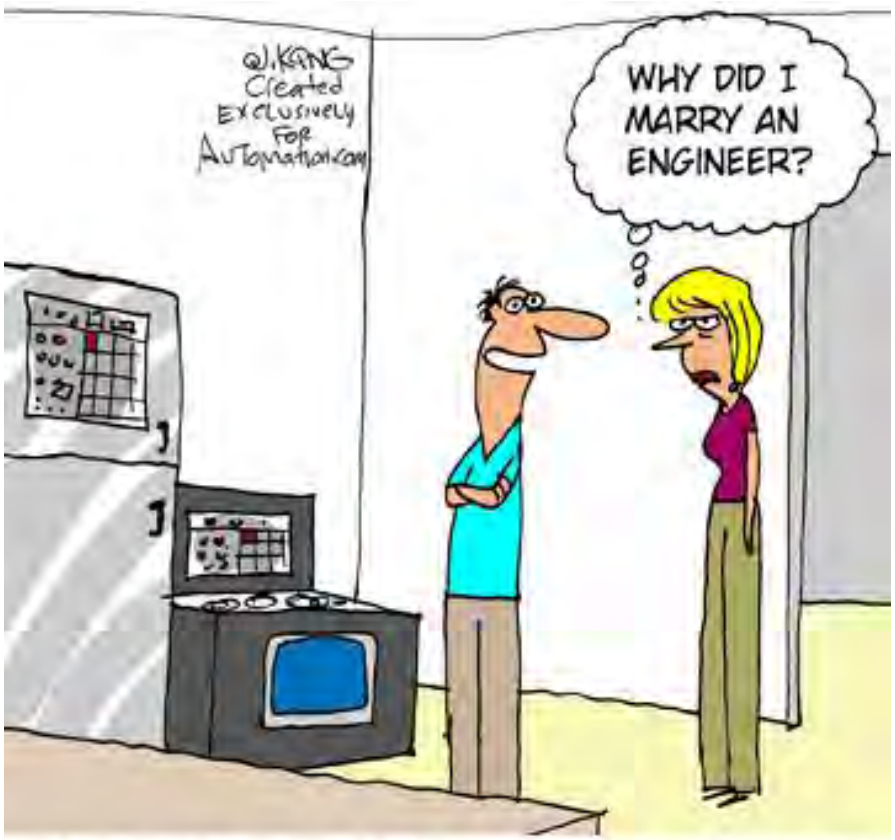
- Public vs. private charging points?
- New agents: aggregator, charging point managers
- Metering equipment, the same could be used?
- Charging Tariffs?
- Standards for plugs, charging points, …?

Gestión activa de la demanda

- Requisitos técnicos
  - Medidores inteligentes
  - Infraestructura de comunicaciones
  - Energy box
  - Señales de precios
- Agentes
  - Comercializadores
  - Agregadores
  - Empresas de servicios energéticos y domótica
  - Distribuidores
  - Fabricantes de equipos
  - Regulador



Gestión activa de la demanda: regulación



"Honey, I converted all our appliances to smart devices. Now I'm just waiting for the SmartGrid infrastructure to come online so we can start paying higher energy rates."

Regulation needs

- Need of ToU tariffs
- "Smart consumers"
- New agents: aggregator
- Metering equipment with defined features
- Need for standards
- Avoid that consumers cover total risk for technical development

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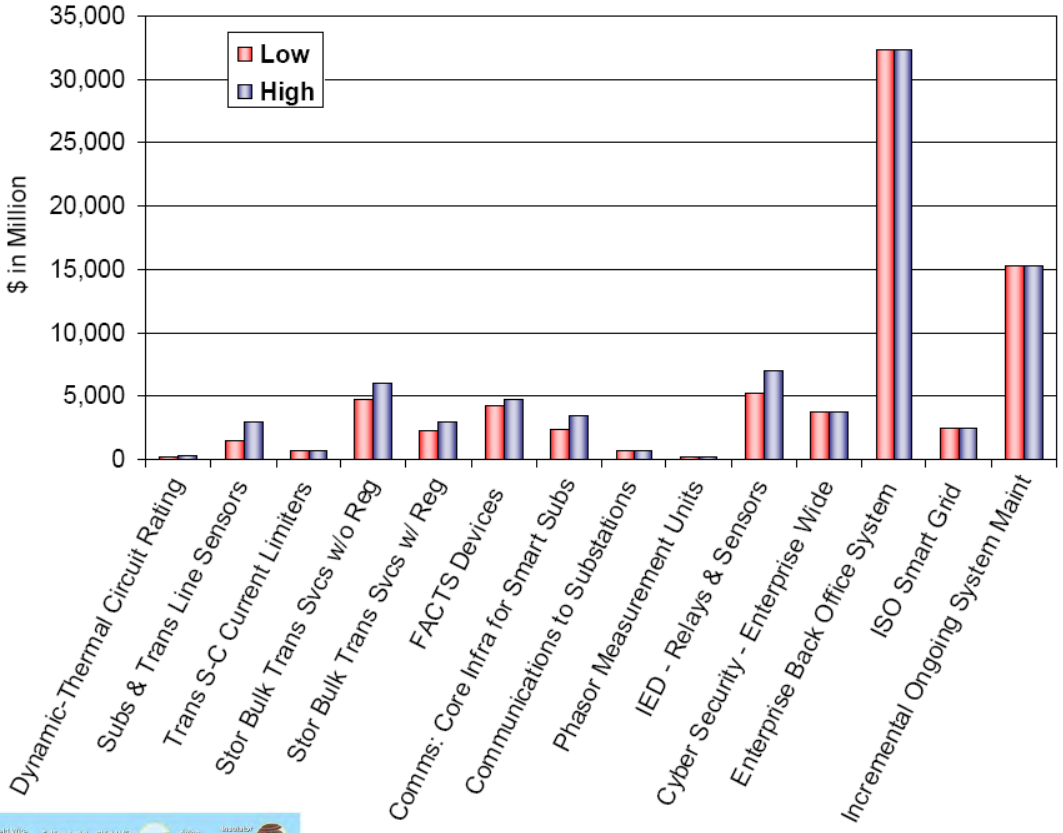
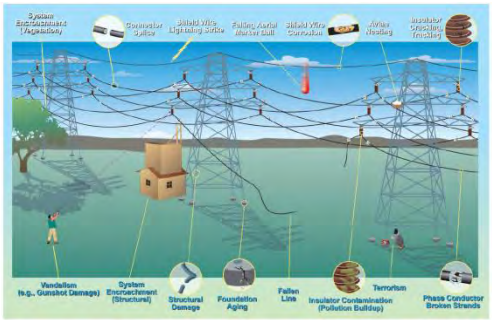
¿Cuánto cuestan?

Costes en redes de transporte

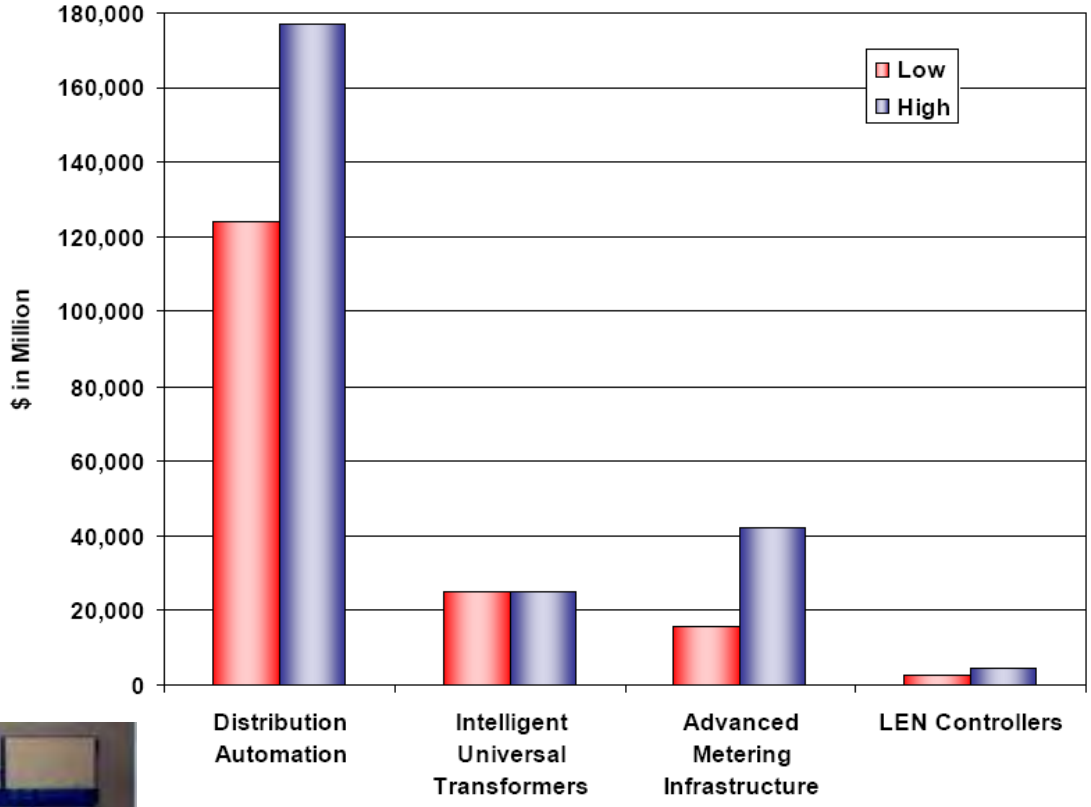
("Estimating costs and benefits of the Smart Grid", EPRI, 2011)





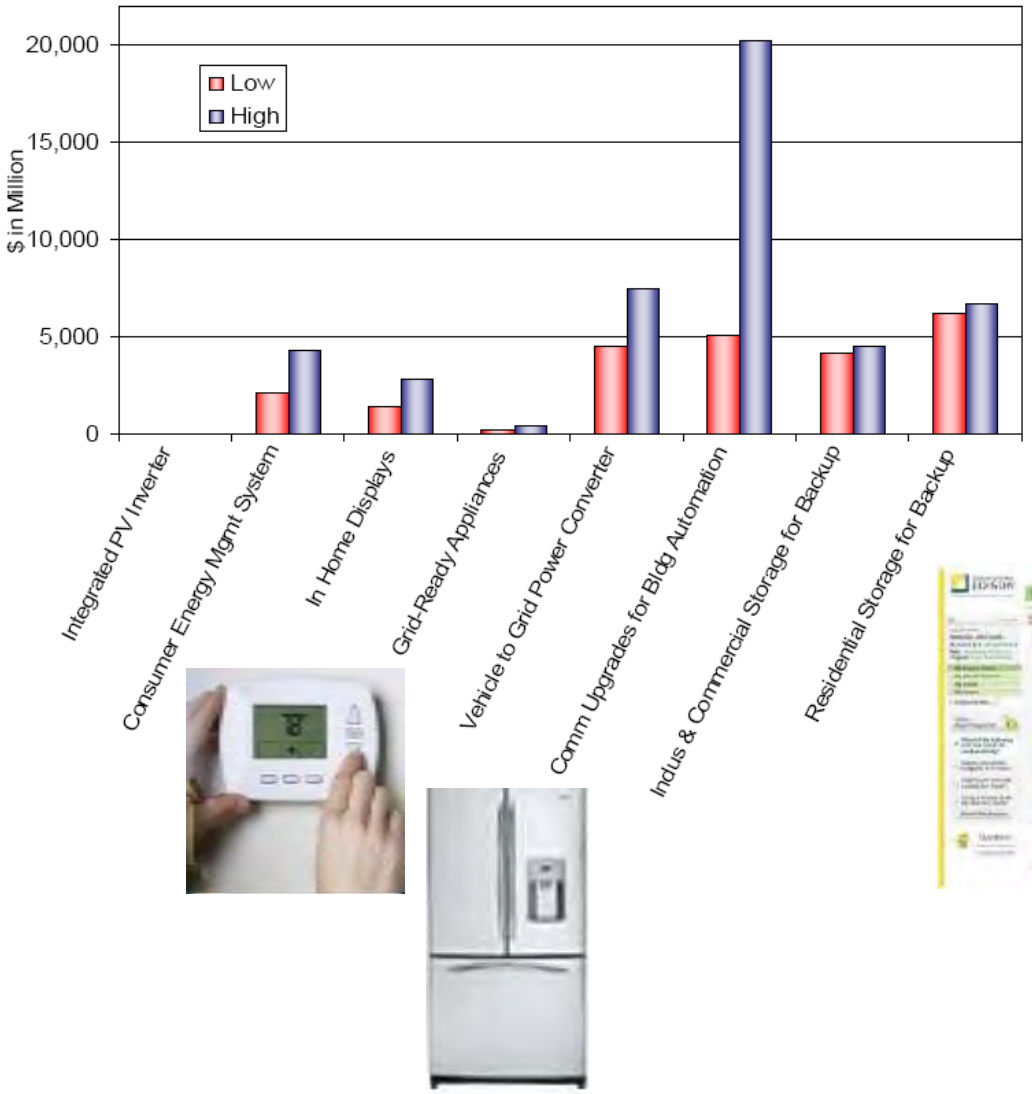
Costes en redes de distribución

("Estimating costs and benefits of the Smart Grid", EPRI, 2011)



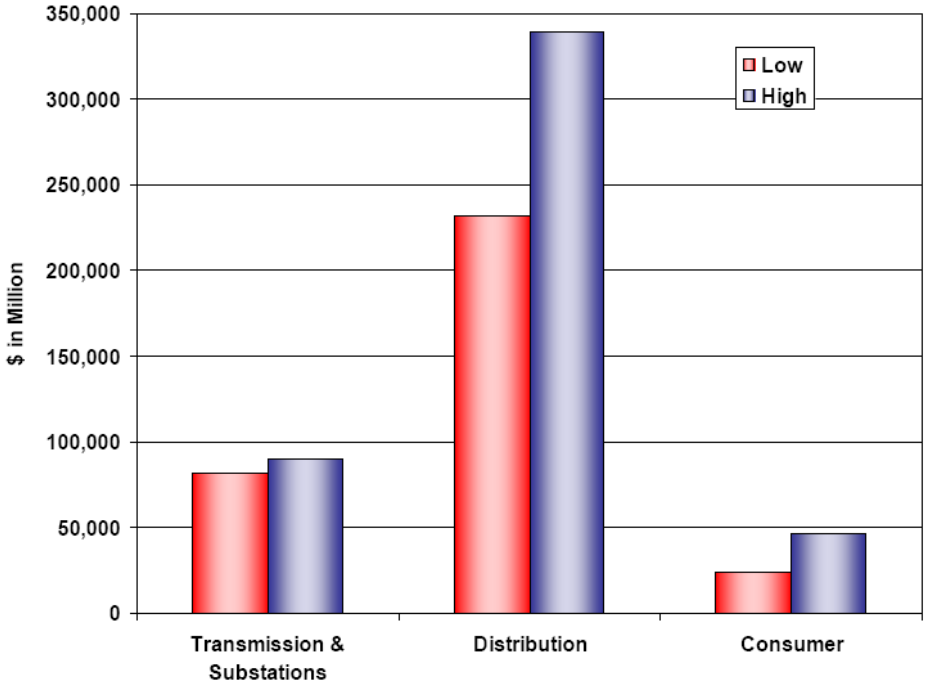
Costes en instalaciones de consumidores

("Estimating costs and benefits of the Smart Grid", EPRI, 2011)



Costes totales estimados

- Europe: 115,000 M€ for EU-27 up to 2030.
- US: (338,000-476,000) M$ (EPRI study)



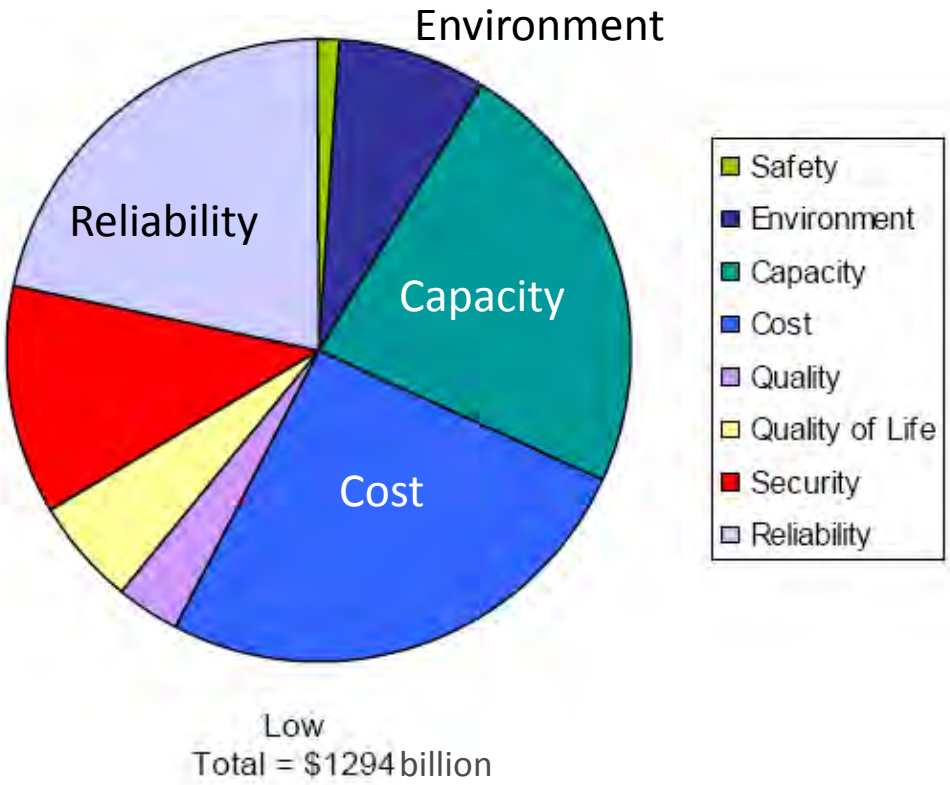
Beneficios esperados

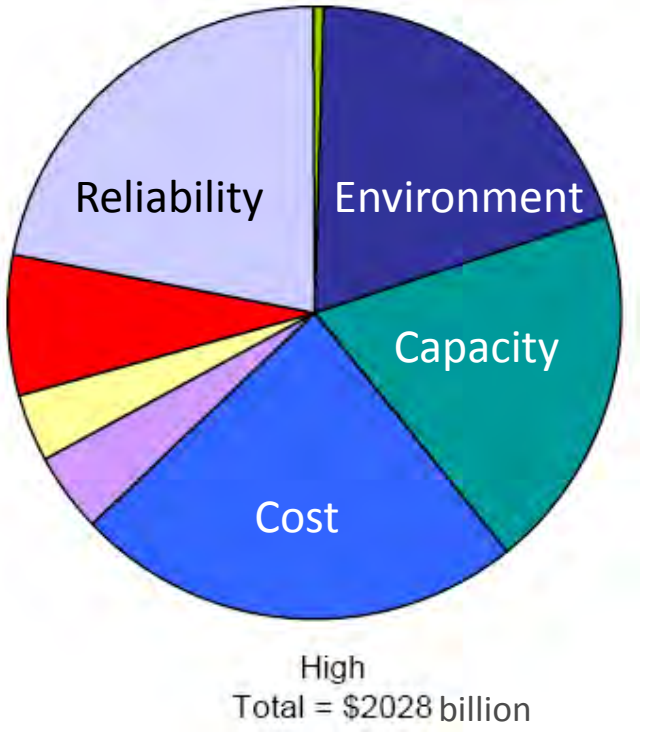
("Estimating costs and benefits of the Smart Grid", EPRI, 2011)

Power Delivery (Improvements/ Benefits) 	Attributes	Consumer (Improvements/ Benefits) 
O&M Cost Capital Cost of Asset T&D Losses	*Cost of Energy (Net delivered life-cycle cost of energy service)*	End Use Energy Efficiency Capital cost, end user infrastructure O&M, End User Infrastructure Control/Manage Use
Increased Power Flow New Infrastructure Demand Responsive Load	*Capacity*	Improved power factor. Lower End User Infrastructure cost through economies of scale and system streamlining, expand opportunity for growth
Enhanced Security Self Healing Grid for Quick Recovery	*Security*	Enhanced Security and ability to continue conducting business and every day functions
Improve Power Quality and enhance equipment operating window	*Quality*	Improve Power Quality and enhance equipment operating window
Reduce frequency and duration of outages	*Reliability & Availability*	Enhanced Security Self Healing Grid for Quick Recovery Availability Included
EMF Management Reduction in SF6 (sulfur hexafluoride) emissions Reduction in cleanup costs Reduction in power plant emissions	*Environment*	Improved Esthetic Value Reduced EMF Industrial Ecology
Safer work environment for utility employees	*Safety*	Safer work environment for end-use electrical facilities
Value added electric related services	*Quality of Life*	Comfort Convenience Accessibility
Increase productivity due to efficient operation of the power delivery infrastructure Real GDP	*Productivity*	Improved consumer productivity Real GDP

Beneficios esperados

("Estimating costs and benefits of the Smart Grid", EPRI, 2011)





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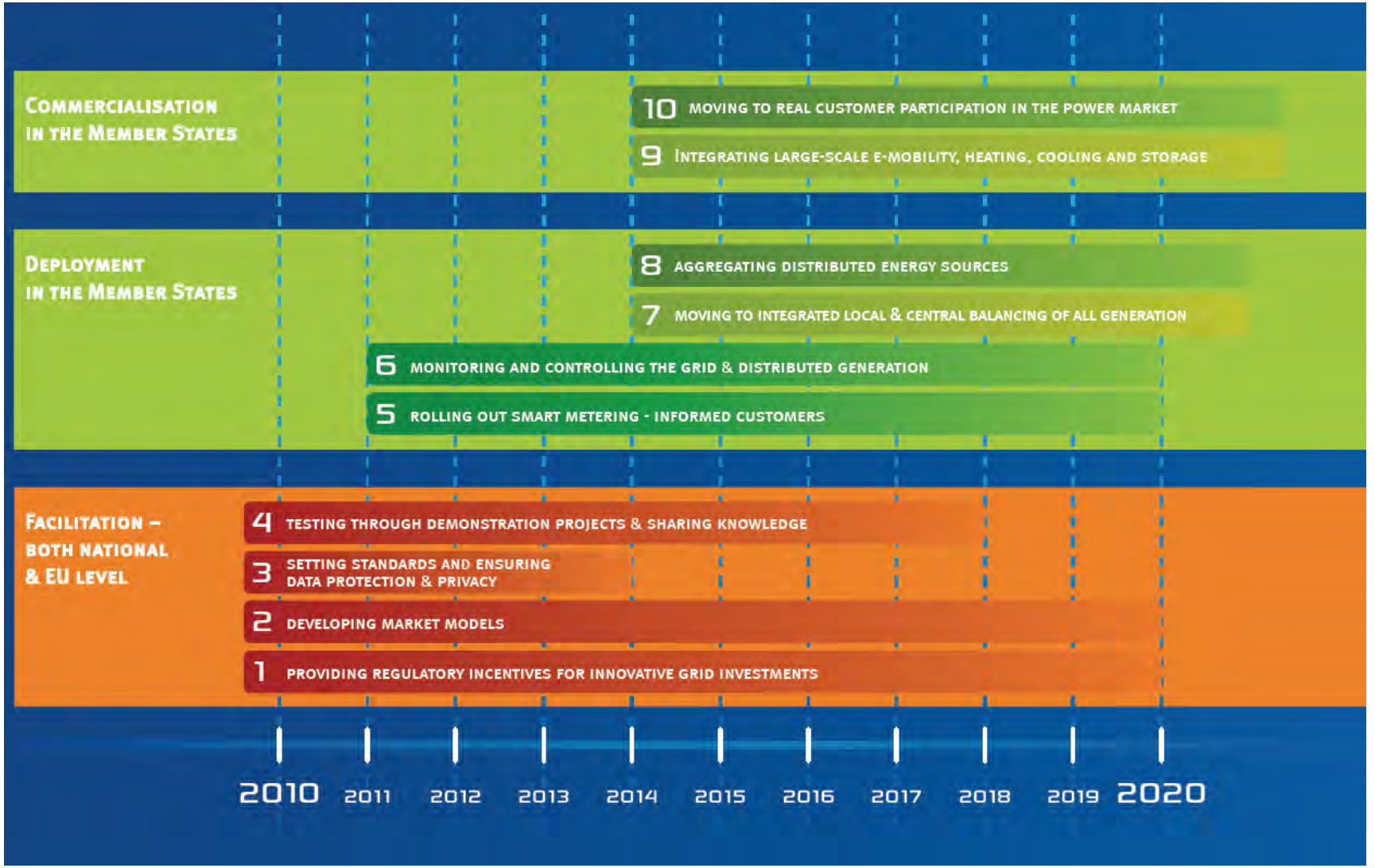
¿Cómo avanzar?

Roadmaps y experiencias piloto

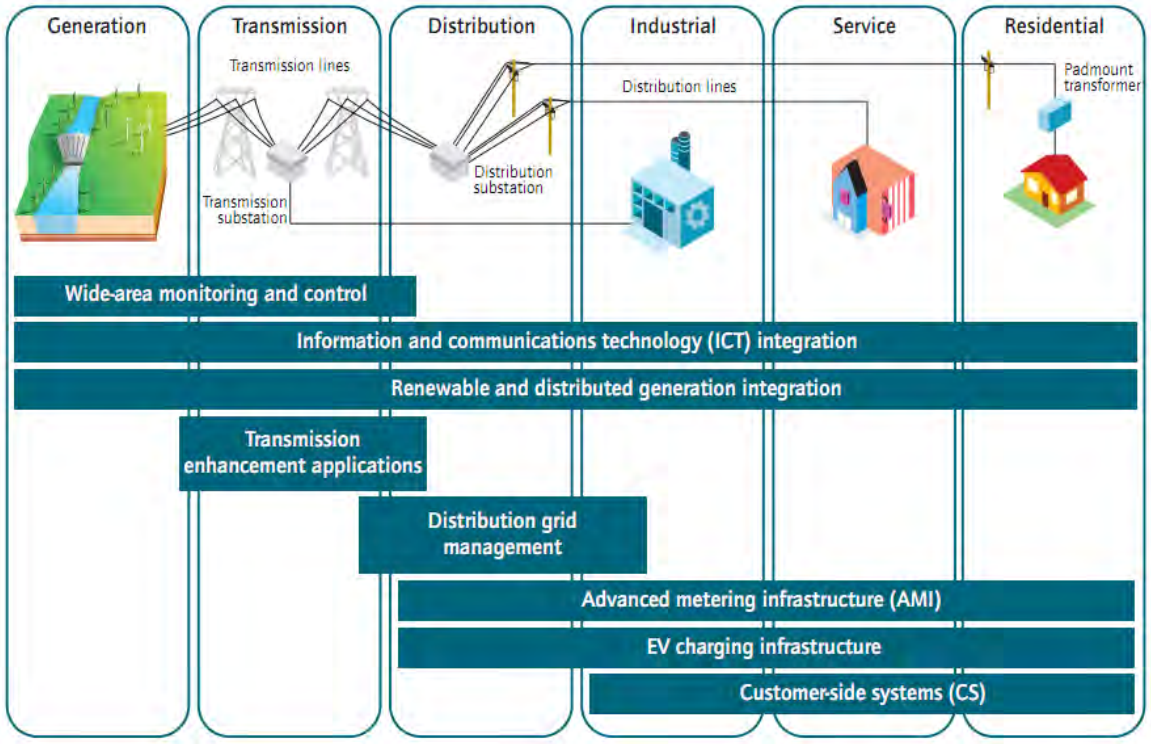
Eurelectric roadmap



("10 steps to Smart Grids", Eurelectric, 2011)

IEA roadmap

- Research still needed:
  - Financial risk (DSOs, manufacturers, …)
  - Stranded assets (DSOs)



Maturity level	*Development*
Developing	Fast
Mature	Fast
Developing	Fast
Mature	Moderate
Developing	Moderate
Mature	Fast
Developing	Fast
Developing	Fast

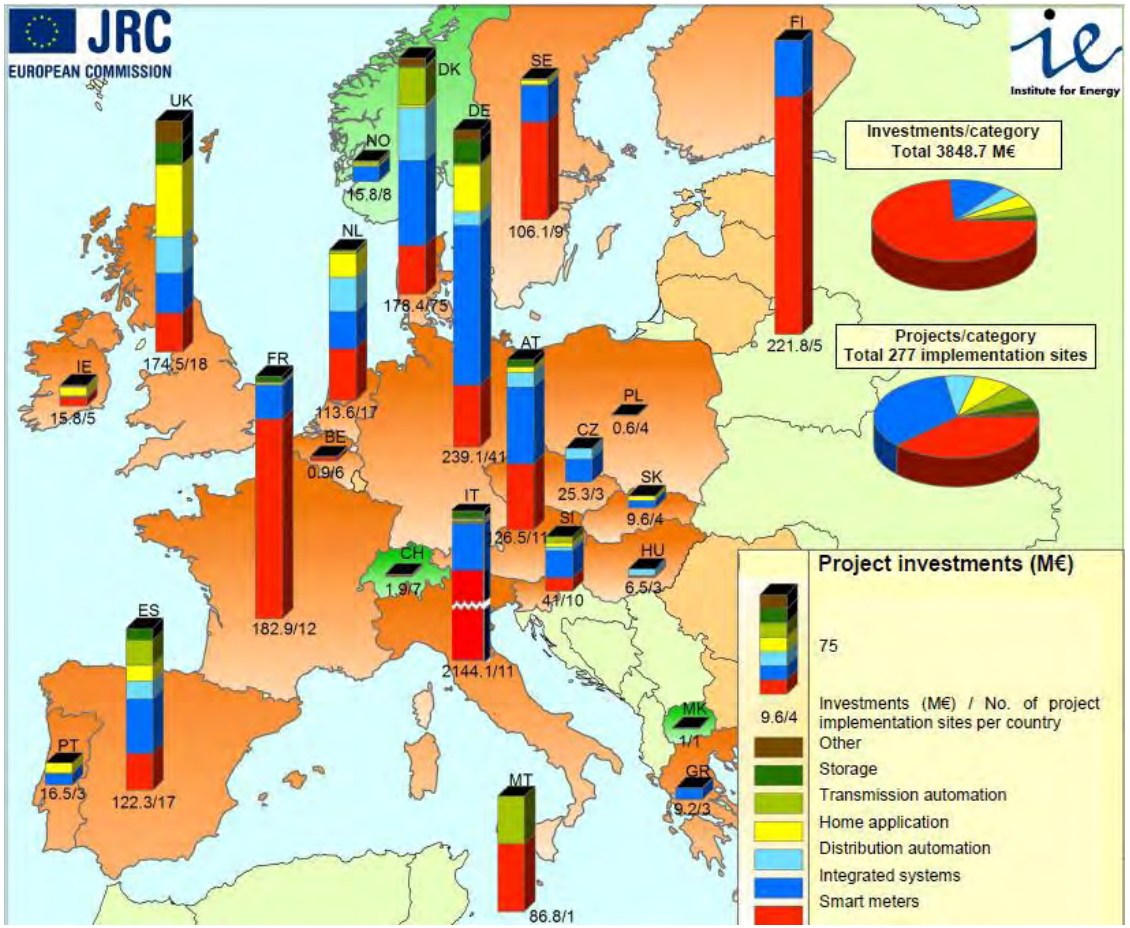
("Techonology roadmap: Smart Grids", IEA, 2011)

SG initiaves in Europe: legislation

- A mandate to **the European Standardisation Organisations** (CENELEC, CEN and ETSI) is being prepared on smart grid standards
- The work programme of the Commission indicates that **by end 2011** new legislation on smart grids will be presented.
  - COM(2009) Directive 2009/72/EC. **Smart metering** across Europe.
  - COM(2010) 677. Energy **infrastructure priorities** for 2020 and beyond
  - COM(2010) 639. Energy 2020. A **strategy for competitive**, sustainable and secure energy.
  - COM(2011) 112. A roadmap for moving to **a competitive low carbon economy** (2050)
  - COM(2011) 202**. Smart Grids**
- The **European Technology Platform for Smart Grids** (2005) and the **SET Plan** European Electricity Grids Initiative (EEGI, 2010) were established as industry-driven initiatives and together with the regional Smart Cities initiatives boost smart grids deployment from small-scale pilot to large-scale demonstration projects.

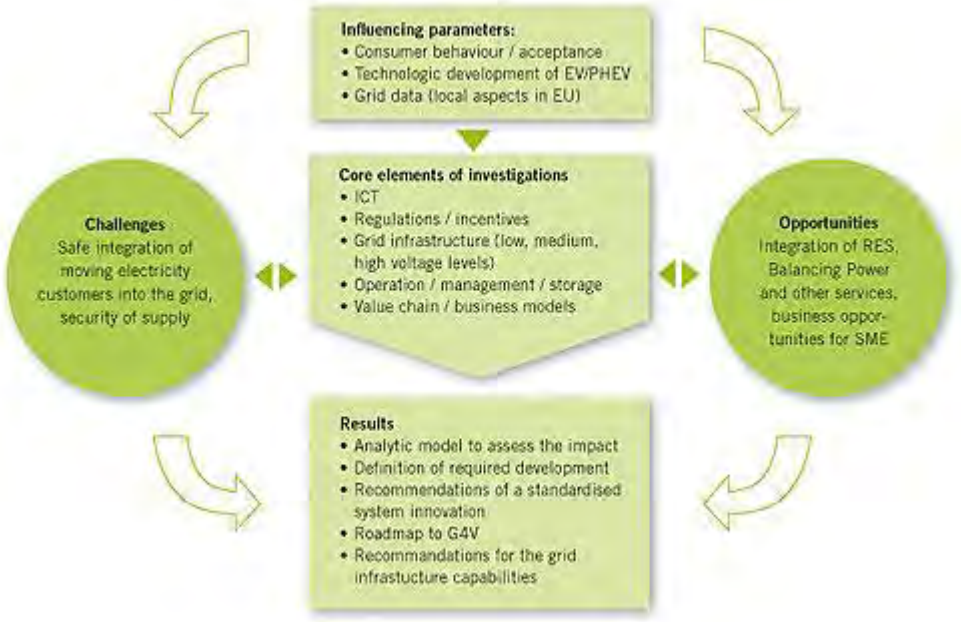
SG research initiatives and projects in Europe

- The European Technology Platform SMARTGRIDS
- The 7th Framework Research program (DG-Research)
- The Intelligent Energy for Europe program (DG-TREN)
- Examples:
  - Grid4EU
  - ADDRESS
  - RESPOND, …
  - SUSPLAN
  - IMPROGRES, SOLIDER, DG-GRID, …
  - MERGE, G4V, …
  - Open Meter, …



SG initiatives: MERGE & G4V projects

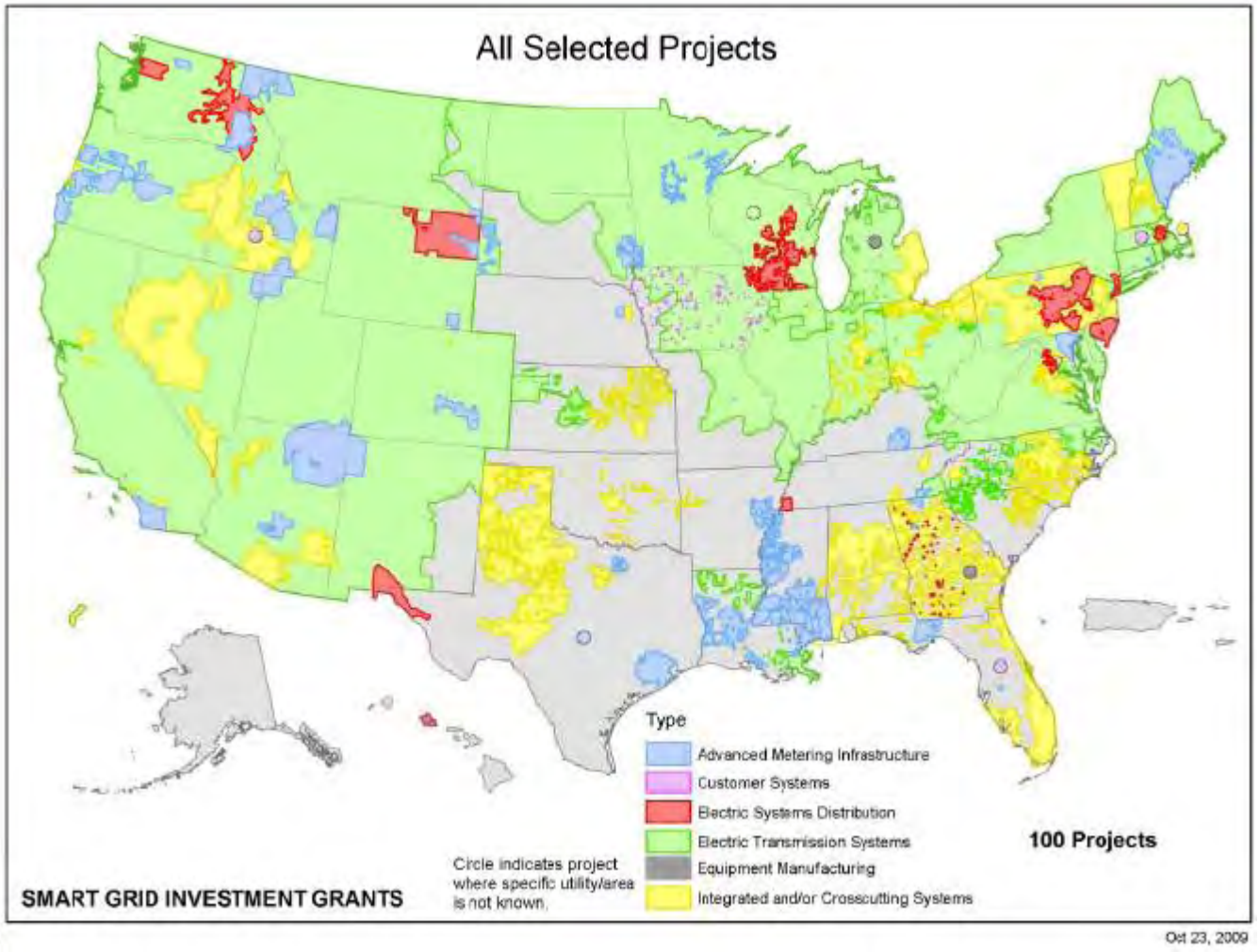
- MERGE: "Mobile Energy Resources for Grids of Electricity“
  - Development of a management and control concept that will facilitate the actual transition;
  - Development of an evaluation suite that consists of methods and programs of modelling, analysis, and optimization of electric networks into which electric vehicles and their charging infrastructure is integrated
- G4V: Analysis of the impact and possibilities of a mass introduction of EV and PEV inEurope



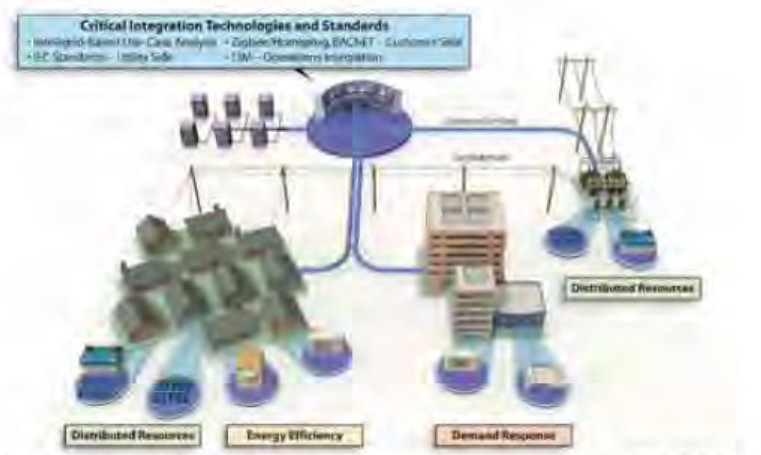
SG initiaves in US: regulation

- 2001. Intelligrid Consortium and Program (EPRI)
- 2007. Energy Independence and Security Act.
- 2008. First DOE report on Smart Grids.
- 2009. American Recovery and Reinvestments Act
- 2010. US FERC. National Action Plan on demand response
- 2011. EPRI report con Smart Grid cost and benefits

SG initiaves in US: projects



SG initiaves in US: some examples



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PNM Resources Smart Grid Demonstration Project

High-Penetration PV thru Grid Automation and Demand Response"

The project is integrating high-penetration distributed Photovoltaic (PV) systems, local storage, and substation-sited PV and storage with both local distribution system management and overall load management at the system level. At the local level, the project will evaluate smart inverter interface technologies to enhance system benefits, applying previous work in the area of smart inverter interface software to residential and substation-based PV. This project aims to match local loads with rate structures to identify and resolve tech nical issues related to high penetration of renewable generation at the utility distribution level. The project will investigate and analyze additional consumer-based demand response opportunities using a modern communication infrastructure integrated with a Home Area Network (HAN), commercial building control systems and smart devices.

Project Reports Available:

PNM Resources Demonstration Host-Site Description, Product ID 1020187
PNM Resources Demonstration Overview, Product ID 1020230
PNM Project Progress Report, February, 2010. Product ID 102353
PNM Project Progress Report, August, 2010. Product ID 1021490

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Southern California Edison (SCE) Smart Grid Demonstration Project

Irvine Smart Grid Demonstration (ISGD)

This project will deploy Smart Grid technologies to improve the operating performance of local distribution systems and encourage customer participation in the control of electricity demand. The project will illustrate how today's infrastructure will function when combined with a diverse range of Smart Grid technologies; create a better understanding of issues related to integration among utilities and Independent System Operators; and provide an analysis of associated benefits to customers and the environment. The integration efforts will span fundamental energy delivery segments such as system protection and automation, a centralized integrated control platform, distributed energy resources and an array of "edge of the network" devices. The ISGD project is divided into four topic areas including energy smart customer devices, year 2020 distribution system, secure energy network, and workforce of the future. Interacting components will create greater value by supplying additional information used to optimize operation of the components, thus enhancing the reliability of the entire system. The intent of the project is to produce an integrated system of protection, performance, efficiency, and scale that extends across the energy delivery system to provide multiple stakeholder benefits.

Project Reports Available:

SCE Demonstration Project Description, Product ID 1021398
SCE Demonstration Project Overview, Product ID 1021420

SG initiaves in Spain: main projects

- FUTURED Spanish Electrical Grid Platform
  - REDES 2025 - PSE (Futured)
- CENIT funding
  - GAD
  - DENISE
  - ENERGOS
  - VERDE
- Iberdrola
  - STAR in Castellón city
  - Red Inteligente en Vizcaya: Bilbao and Portugalete
- Endesa
  - Smart City in Málaga city
  - OPTIGES - Premios Novare
- MOVELE
- CITYELEC
- Proyecto INGRID – Vasque government (Tecnalia)

FutuRed

To foster the technological evolution of Spanish electricity transmission and distribution systems in order to promote technological leadership, sustainable development and increased competitiveness.

Conclusiones

- Redes eléctricas inteligentes: desafío tecnológico, económico y regulatorio
- Su necesidad viene asociada a los retos que nuestro sistema eléctrico tiene con motivo del 20/20/20
- Costes y beneficios: necesitan ser evaluados en diferentes contextos y escenarios
- Necesidad de proyectos demostrativos con suficiente escala y resultados replicables
- Oportunidad de nuevos negocios y desarrollo tecnológico
- Regulación: debe equilibrar incentivos a los agentes regulados con reparto de beneficios entre las partes involucradas promoviendo eficiencia

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