

# **Engineering, Economics & Regulation of the Electric Power Sector**

ESD.934, 6.974

**Session 23**

**Module M**

## **Electricity markets & public policy**

**A necessary coexistence**

**Prof. Ignacio J. Pérez-Arriaga**

## **Our energy model is unsustainable**



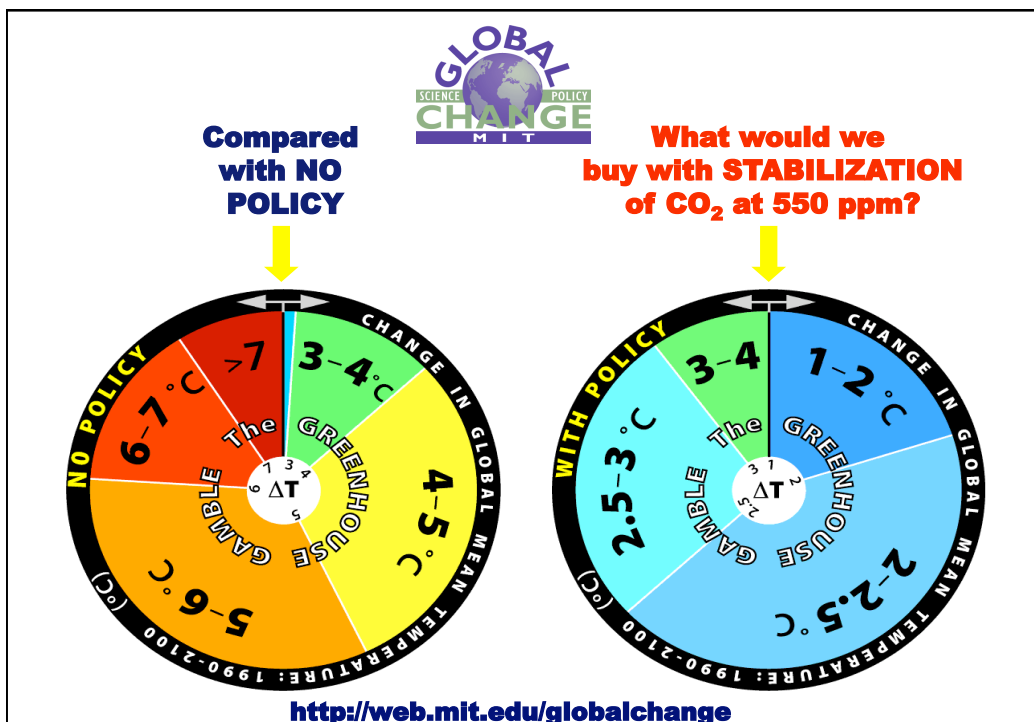
- ◆ The current energy model cannot provide energy services that
  - are compatible with the expected growth in population & welfare in the medium & long-term,
  - with a reasonably equitable universal access
  - and with a tolerable environmental impact
- ◆ The problems
  - non equitable access
  - tight coupling of economic development & energy demand growth
  - very high dependence of fossil fuels
  - key energy resources are limited & geographically concentrated

2

## Consider climate change...

- ◆ There is widespread agreement that a transition to a future economy with a **drastic reduction in GHG emissions** is needed to stabilize GHG concentration at levels such that the implications of climate change could be kept under “reasonable” limits

3



Courtesy of the MIT Joint Program on the Science and Policy of Global Change. Used with permission.

## **But this is an arduous task & it will not happen by itself**

- ◆ An emission path with good chances of meeting the <2°C target:

*"in order to achieve a stabilization level of 450 ppmv CO<sub>2</sub> eq, emissions from Annex I Parties would need to be between 25 per cent and 40 per cent below 1990 levels in 2020, and between 80 per cent to 95 per cent below 1990 levels in 2050."*

**Source: IPCC (2007)**

5

## **Energy policy in a low-carbon economy**

- ◆ A sustainable economy has to be based on a sustainable energy model, where the power sector is a key component
- ◆ The current regulatory paradigm of the power sector has to be reconsidered in this new context, where public energy policy will play a major role

6

## Limitations of energy markets (1 of 2)

- ◆ Advantages of markets are well known
  - Energy markets are successful if structure is right & there are no interferences
  - although they are complex & may go wrong in many ways
- ◆ But there are limitations
  - Network activities are natural monopolies
  - (*perhaps*) Adequate margin of installed generation supply may require some regulatory intervention

7

## Limitations of energy markets (2 of 2)

- ◆ ... and more limitations (*of interest here*)
    - Energy markets may ignore sustainability concerns
      - long-term availability of present energy sources
      - energy dependence / diversification of fuels
      - need to promote technologies that are suitable for long-term sustainability objectives
- since energy prices fail to fully internalize these concerns.  
Why?
- Technical /practical difficulties in implementation
  - high energy prices are not politically acceptable
  - lack of long-term regulatory commitment
- **Need to provide energy markets with some long-term vision**

8

## **What could *(but maybe should not)* be regulated?**

- ◆ Support schemes for renewable energy penetration & cleaner fossil technologies
- ◆ Targets for energy efficiency & savings & how to achieve them
- ◆ Support schemes to improve the security of electricity & gas supply
- ◆ Development of gas & electricity network infrastructures
- ◆ Priorities & resources for energy R&D
- ◆ Targets for carbon allowance emissions
- ◆ Implementation guidelines resulting from the debate on future nuclear investments

9

## **The questions to be addressed**

- ◆ In the context that can be anticipated of strong sustainability & security oriented policy measures
  - 1. How to improve / redesign market regulation to facilitate that these policies reach their objectives efficiently?**
  - 2. How to make these policy measures compatible with the functioning of electricity markets?**

See the special issue of The Energy Journal “The future of electricity: Papers in honor of David Newbery”, 2008, for a detailed elaboration on these issues

10

## Some premises (1 of 3)

- ◆ Creating well functioning competitive wholesale & retail markets for electricity is very challenging, both technically & politically, & cannot be applied anywhere
  - Where properly implemented, wholesale markets have led to improved performance & have mobilized significant investments
  - Sound incentive-based regulation of distribution companies has reduced costs without impairing quality of service
  - Despite some failures & implementation difficulties, the general trend in most liberalized power sectors is to proceed with the process of reforms

11

## Some premises (2 of 3)

- ◆ There is a serious (& *justified*) global concern about climate change & this will affect energy policy & power sector investments profoundly → intense **political oversight & interference** is anticipated
- ◆ **Security & sustainability** will have at least the same priority as **efficiency** in the regulatory design
- ◆ New & emerging **clean technologies** will be crucial in attaining a sustainable power system model, but their development & commercial deployment will typically need **regulatory support**

12

## Some premises (3 of 3)

- ◆ It is anticipated a large penetration of renewable &/ or **intermittent** &/or **distributed** generation in many power systems
- ◆ The availability of communication & control technologies plus current trends in regulation & consumer behavior signal a strong future **active demand response**
- ◆ Political developments, economic rationality & network reinforcements lead to an **integration of existing power systems & markets** into larger entities

13

## The regulatory context for clean energy

## Advancing the conclusion

“A compelling vision, backed up by precise, simple, clear policy, needs to be implemented if larger institutions and investors are to create the argument internally that a greater proportion of the balance sheet needs to be available for sustainable energy”

Source: Chatham House, “Unlocking finance for clean energy”, 2009,  
[www.chathamhouse.org.uk](http://www.chathamhouse.org.uk)

## An adequate regulatory context for clean energy

- ◆ For the most part ***the market for clean energy is policy-driven*** (for a good reason)
- ◆ In a policy-driven market ***regulation itself is a risk***
- ◆ Therefore, to unlock finance for clean energy there is a ***need for “investment grade” policy***



## **Policy needs to be “loud, long & legal”**

### **◆ Loud**

- Policy instruments make a difference, so that investments in clean energy become commercially attractive

### **◆ Long**

- Policy instruments are sustained for a period that is consistent with the financial characteristics of the project

### **◆ Legal**

- Policy instruments are based on a clear, stable & well-established regulatory framework

Based on “Unlocking finance for clean energy”, [www.chathamhouse.org.uk](http://www.chathamhouse.org.uk), 2009

## **Key features of “investment grade” energy policy**

- ◆ “Clear, unambiguous policy objectives, with clear enforcement provisions
- ◆ Policy and regulation streamlined across all factors within the boundary of the deal: from planning approval to delivery
- ◆ Carefully designed incentive or support mechanisms to achieve targets or objectives
- ◆ Policy stability across a project-relevant duration
- ◆ Simplicity: to reduce complexity and variables that might add risk
- ◆ Near-term attention to infrastructure – the planning, integration and regulatory requirements – to ensure the overall system is optimized for significant uptake of RE, and demand-side options”

Based on “Unlocking finance for clean energy”, [www.chathamhouse.org.uk](http://www.chathamhouse.org.uk), 2009

## More on a sound clean energy policy

◆ Besides a sound regulatory support scheme, any massive deployment of a clean technology requires also attention to

- **development of the required underlying infrastructure** (*connection to electricity networks, plugs for PHEVs, feedstock for biomass plants, etc.*)

including any authorization procedures, among other surrounding factors that need to be solved for the support scheme to be effective

## There are some reasons for concern

◆ “Clean energy” technologies are very diverse  
(*renewables of different types, energy saving & efficiency, smart grids as an enabler, CCS, nuclear?*)

- Designing a comprehensive energy strategy is more complex than just choosing the least cost solution → **policies may shift**

- e.g., presently renewables are not the least expensive option to mitigate climate change, but they will be indispensable in the long run and have also side benefits (& inconveniences) at local level: How stable the support will be?

→ **regulatory instruments should adapt to technological changes** (*not the same risk when investing in mature vs. emergent technologies*)

Question #1:

**How to improve /redesign  
market regulation to facilitate  
the implementation of  
sustainable policies?**

**A tentative list of regulatory  
challenges (1 of 7)**

- ◆ The need for **adequate transmission & distribution networks**
  - Establish proper remuneration of **distribution** networks with distributed generation & active demand response
    - Design, operation & control of distribution networks have to be adapted & costs will increase → need for new network models & regulatory schemes (*see detail in next slide*)
  - Attain adequate investment levels in **transmission** networks with much intermittent/renewable generation
    - The existing network (e.g. in the US & EU) lacks adequate interconnection capacity among regions, a comprehensive approach to coordinated transmission expansion & the institutional capability for an effective implementation

## Detail

### Ideas for a regulatory response

- Refine the **models of remuneration** of distribution networks, so that the extra costs/benefits of accommodating DG & efficiency measures are recognized & negative incentives are minimized
- Find instruments to incorporate deployment of effective **innovative** technologies in the remuneration schemes
- Transmission capacity expansion must be based on **comprehensive planning** studies & **responsibilities** for implementation should be clearly assigned
- Pricing & remuneration of transmission should be transparent, low risk & convey efficient **locational signals**

23

## A tentative list of regulatory challenges (2 of 7)

- ◆ Efficient **locational signals** & constraints management
  - Locational marginal pricing (nodal energy pricing) is the preferred solution, although it will find political resistance in the EU (*not yet implemented in established markets; winners & losers*)
  - Locational transmission network charges (*very much talked about, but only implemented in few power systems*)
- ◆ Geographical expanse → **markets integration** (*needed to mitigate market power & to dilute generation intermittency*)
  - The inter RTO seamless problem (US)
    - Not attempted seriously yet
  - The regional initiatives (EU)
    - Still struggling at regional level

## A tentative list of regulatory challenges (3 of 7)

- ◆ Changes in the generation **technology mix** induced by renewable / intermittent / distributed generation
  - Less “residual demand” / some impact on base-load technologies / more back-up capacity to provide operating reserves in the mix
  - Regulatory instruments to achieve generation investment adequacy
    - The case for support of peaking units (*although all generation units are affected*) becomes more apparent
    - A large variety of regulatory schemes is presently used or under consideration

25

## A tentative list of regulatory challenges (4 of 7)

- ◆ Changes in **system operation** with strong presence of renewable / intermittent / distributed generation & active demand response
  - Present system operation is not adequate to deal with really large volumes of intermittent generation, integration of demand response & seamless coordinated congestion network management in large interconnected power systems → new paradigms in system operation
    - Aggregators of active demand, micro-generation (including PHEVs) & distributed storage
    - New approaches & flexibility in provision of ancillary services
    - Perhaps security-driven hydro generation management

26

## **A tentative list of regulatory challenges** (5 of 7)

- ◆ **Active demand response:** taking advantage of it & making it possible
  - Efficient deployment of advanced metering, real-time tariffs & behind-the-meter load management
  - Meeting the objectives of energy efficiency & savings → Competitive & focused retail companies (energy service providers) → adequate design of default tariffs, unbundling, compatibility standards, design of smart grids
  - Additional challenges: electrification of mobility
  - Efficient integration of active demand response is a major component in the new paradigm for system operation

### **Detail**

## **Ideas for a regulatory response**

- ◆ Technologies & economic signals resulting in energy conservation & efficiency (ECE) improvements from the consumers' side typically lead to reductions in the regulated revenue of distributors & uncompensated demand destruction for retailers
- ◆ As with DG penetration, these measures may not be welcomed by distributors & retailers, unless
  - the efficiency gains are shared with distributors & retailers
  - the remuneration of the distribution activity is more precisely computed & made less dependent on the simplistic "distributed energy" metric

28

## **A tentative list of regulatory challenges (6 of 7)**

- ◆ Other obstacles or barriers that markets do not solve by themselves (*or fast enough*) without external intervention
  - Increment the regional / spatial dimension
  - Fix market structural problems (vertical integration, excessive concentration)
  - Political resistance to accept needed regulatory changes

29

## **A tentative list of regulatory challenges (7 of 7)**

- ◆ Lack of access to electricity in developing countries (DCs) is a key component of the lack of sustainability of the present energy model
  - Rural electrification
    - Has to be explicitly considered an energy policy in DCs
    - Has always needed support schemes
    - Specific financial & organizational models are needed to attract private investment
  - Regarding CC a key issue is to promote large-scale grid-connected renewable deployment
    - Issues: new hydro developments, adapt support schemes, financing

30

Question #2:  
**How to make markets &  
public energy policies  
compatible?**

**How much regulation does  
liberalization need?**

- Proper market design and policy enforcement for the competitive part of the system (competition policy)
- Proper regulatory mechanism design and policy enforcement for the natural monopoly part of the system (regulatory policy)
- Proper market arrangements and policy design for the handling of environmental effects of electricity and gas production and use (environmental policy)
- Market arrangements and policy design for securing security of supply/resource adequacy (public goods aspects)
- Proper overall design and policy enforcement



## First, indicative planning

- ◆ What is intended to accomplish? (*national & supranational energy policies require long-term analysis with sustainability criteria*) → **indicative planning (IP)**
  - The IP procedure is meant to characterize meaningful energy development paths that meet any prescribed high level (*sustainability & others*) targets, in order to facilitate political decisions
  - Note that, once one path is chosen, IP
    - is more than just **prospective** analysis (*find what could happen*)
    - has **normative** character (*identify what has to be done to make sure that a future with some desirable features happens*)

33

## A tentative list of regulatory challenges (1 of 4)

- ◆ **Choice of instruments** to develop & deploy **clean technologies** (electricity generation & energy efficiency & conservation, ECE) to meet IP targets
  - Use **market prices** (*of energy, emissions, green or white certificates*) with as much internalization as politically possible
  - **BUT** while full internalization of sustainability implications is not achieved → use **additional regulatory instruments** (*quotas, standards, incentives, cross-cutting policies*) while trying to minimize market distortion

34

## A tentative list of regulatory challenges (2 of 4)

- ◆ Choice of instruments to make possible a **clean technology mix** in electricity generation
    - **Nuclear**: if politically acceptable, it might need some regulatory commitment to reduce financial risks
    - **Clean coal (CCS)**: presently only viable with regulatory support (*until sufficiently high & stable CO2 prices exist*)
    - **Renewables**: same; support scheme should depend on level of maturity of technology, cost & rules for integration in the market (*which affect the economic viability of other plants*)
    - **Peaking plants**: economic viability strongly depends on regulation of security of supply & intermittent generation
- *Reduced, but not negligible, space for the market* <sup>35</sup>

## A tentative list of regulatory challenges (3 of 4)

- ◆ Choice of instruments to make **energy efficiency & conservation (EEC)** (*technology with largest potential & most cost-effective*) possible at a required level
  - Here energy prices, even with full internalization, might not be sufficient to achieve the desired consumer response (*lack of information, high consumers' discount rates, uncertainty in investments' results, weak incentives, principal-agent problem, rebound effect*) use additional instruments & target energy savings rather than efficiency, plus information
    - Make use of standards or of other measures also directly seeking a net reduction in energy consumption (still, danger of free riding, inefficiency)
    - It is OK to use a mix of regulatory instruments in this "second-best" world <sup>36</sup>

## **A tentative list of regulatory challenges** *(4 of 4)*

### ◆ Other regulatory concerns

- Transitory arrangements (windfall profits)
  - Windfall profits: consumers must be protected in different ways; this is a side effect of the application of CC-related instruments
- Regulatory stability & predictability
- Role of independent regulators: These issues should be explicitly included within the responsibilities of energy regulatory agencies
  - Governments should set the high level targets & approve an “indicative” sustainable plan
  - Regulators should design the regulatory instruments to make this possible within a market environment

37

**Thank you for your  
attention**

MIT OpenCourseWare  
<http://ocw.mit.edu>

ESD.934 / 6.695 / 15.032J / ESD.162 / 6.974 Engineering, Economics and  
Regulation of the Electric Power Sector  
Spring 2010

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.