CIRED
Centre International de Recherche sur l'Environnement et le Développement

CHAIRE EUROPEAN ELECTRICITY MARKETS
Fondation Paris-Dauphine

Effectiveness of carbon pricing in different structures of power sectors.

Misalignments in emerging and developing countries

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Workshop Chaire CEEM, 14 March 2016

« Market Designs for Low Carbon Elec. Generation »

Introduction

Importance of carbon tax or ETS as the central tools for carbon policies

Strong international mobilisation around carbon pricing instruments

International organisations (World Bank, IMF) were mandated to promote carbon pricing instruments towards emerging and developing countires before Paris

World Bank's Partnership for Market Readiness (PMR)
https://www.thepmr.org/content/participants

- 15 emerging countries Brazil Chile China Colombia India Indonesia Mexico Morocco Peru South Africa Thailand Tunisia Turkey Ukraine Vietnam, etc.

+ 7 OECD countries

+ World Bank's Carbon Finance Unit

Strong belief in carbon pricing and in particular in ETS covering industries

Present example in the US with the Clean Power Plan (

Introduction

Tableau 1. Les niveaux de taxes carbone dans le monde en 2014
(en €/ tCO2 et à partir des taux de change de 2014)

	Colombie britannique	Danemark	Finlande	France	Irlande	Japon	Norvège
Adoption	2008	1992	1990	2014	2010	2012	1991
Niveau actuel	22,5€ (30 CaS)	31 €	35 € comb. 60 € carbu.	22€ (2016)	20 €	2,5 €	6€ comb. 60 € carb

	Royaume uni	Suède	Suisse	Afrique du sud	Chili	Mexique
Adoption	2004	1991	2008	2015	2014	2015
Niveau actuel	7,3-14 €	114 €	68 € (66 CHF)	10€	5€	5€

Source: Recensement personnel

Tableau 2. Pays non OCDE ayant ou envisageant un système de permis

Chine Kazakhstan (en cours)

Thailand, Turkey (envisagé)

Introduction

- Importance to understand effects of the introduction of a carbon pricing mechanism(ETS, carbon tax) in the power sector of emerging and developing countries
  - Its effectiveness in matter of carbon emission reductions
  - Its effects on electricity prices with their eventual interference with other energy policies
    - (in particular the distributional issues for industry and small/poor consumers)

Difference between mature market systems in OECD countries & fast growing systems of emerging/developing countries with:

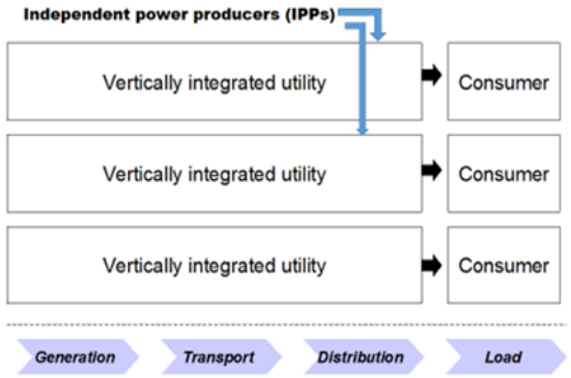
- Strong regulation (single buyer + PPAs + retail monopoly regulation)
- hybrid regime (market+ planning + long term contract + partial retail regulation)

Misalignment of carbon pricing with the organisation and regulation in these cases

Typology of power sector reforms
Very different degrees of de-verticalisation, multi-level competition and privatisation

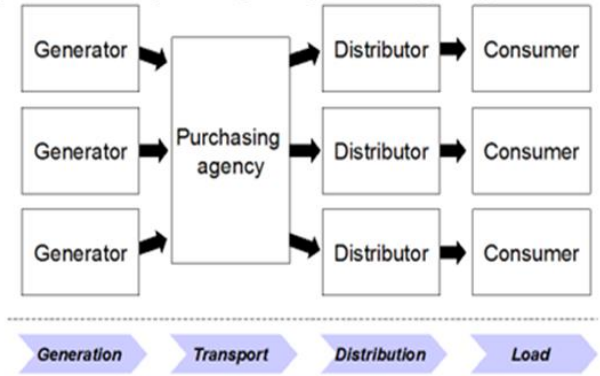
Model 1: Public Service Monopolies at the level of region or nation

Exemples in some emerging and developing countries (South Africa, etc.)



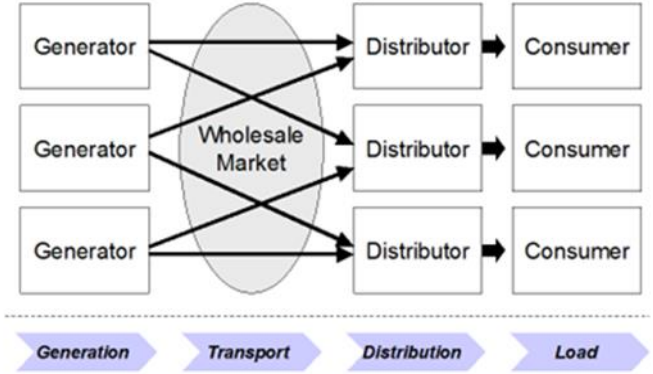
Model 2: Purchasing agency (single buyer) for regulated distriutors/retailers at regional or national level

Exemple: China with public regional grids as single buyers



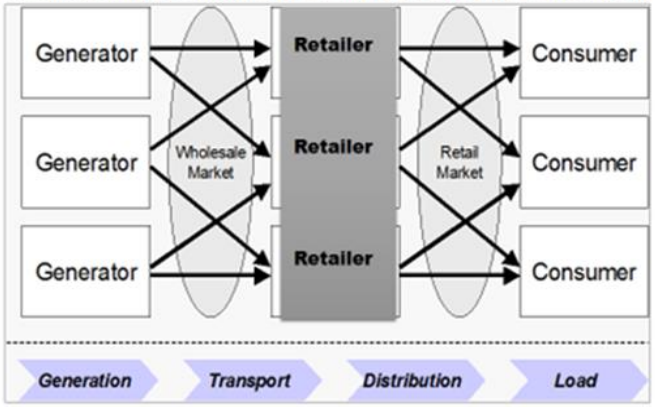
Model 3: Wholesale competition (with auction of long term contracts) and retail monopolies

Exemples: Brazil with central auctioning, Chili with decentralized call for tenders



Model 4: Wholesale & Retail Competition

Exemples: US jurisdictions, EU countries, Australia, New zealand



California, Brazil, Chili, Columbia, Peru
Presently UK

Introduction

Three issues of the effects of carbon pricing in the different organisational models

Short term substitution:

Long term effects by investment in low carbon technologies

Redistributional issue of carbon pricing by ETS or carbon tax

1. Conventional approach of carbon pricing effects in power sector

Carbon pricing can influence emissions from the power sector in three ways, via its effects on variable costs of fossil fuel plants, on electricity revenues by market prices and on retail prices

- 1.by turning the electricity generated by existing carbon intensive power plants more expensive and thus less competitive against cleaner technologies :
  - this is the short term substitution effect (mainly dispatching effects)

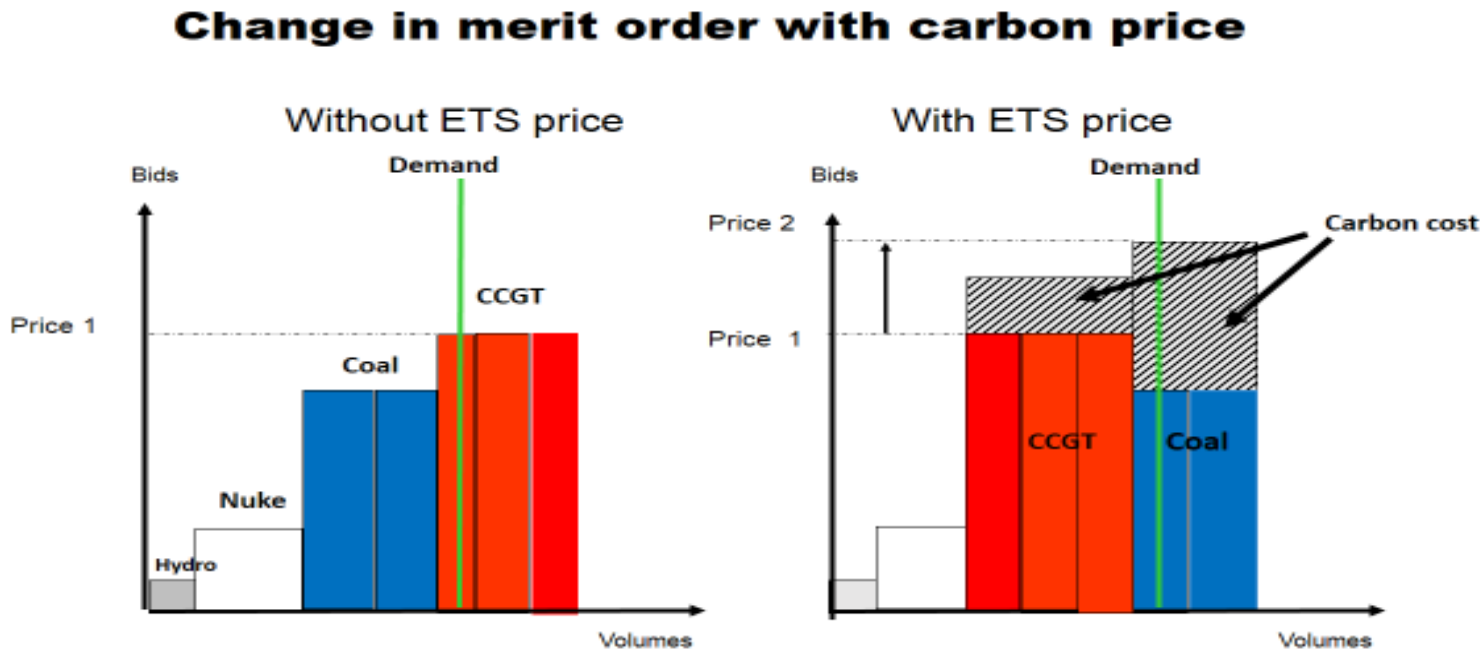
- 2. by turning the investment in clean (or cleaner) technologies more profitable with high upfront cost recovering:
  - this is the long term structural effect

- 3. by turning the electricity price more expensive for the final customer, and thus inducing a reduction in consumption and so in emitting generation,

1.1. Short term effects of merit order between existing fossil fuel technologies

Electricity markets are strutured in (semi-) hourly markets

Short term effects on selection of equipment by the hourly markets : Change in the merit order on the hourly markets



1.2. Long term effects : investment in low carbon technologies rather than in emitting plants

Not so simple than a LCOEs comparison:

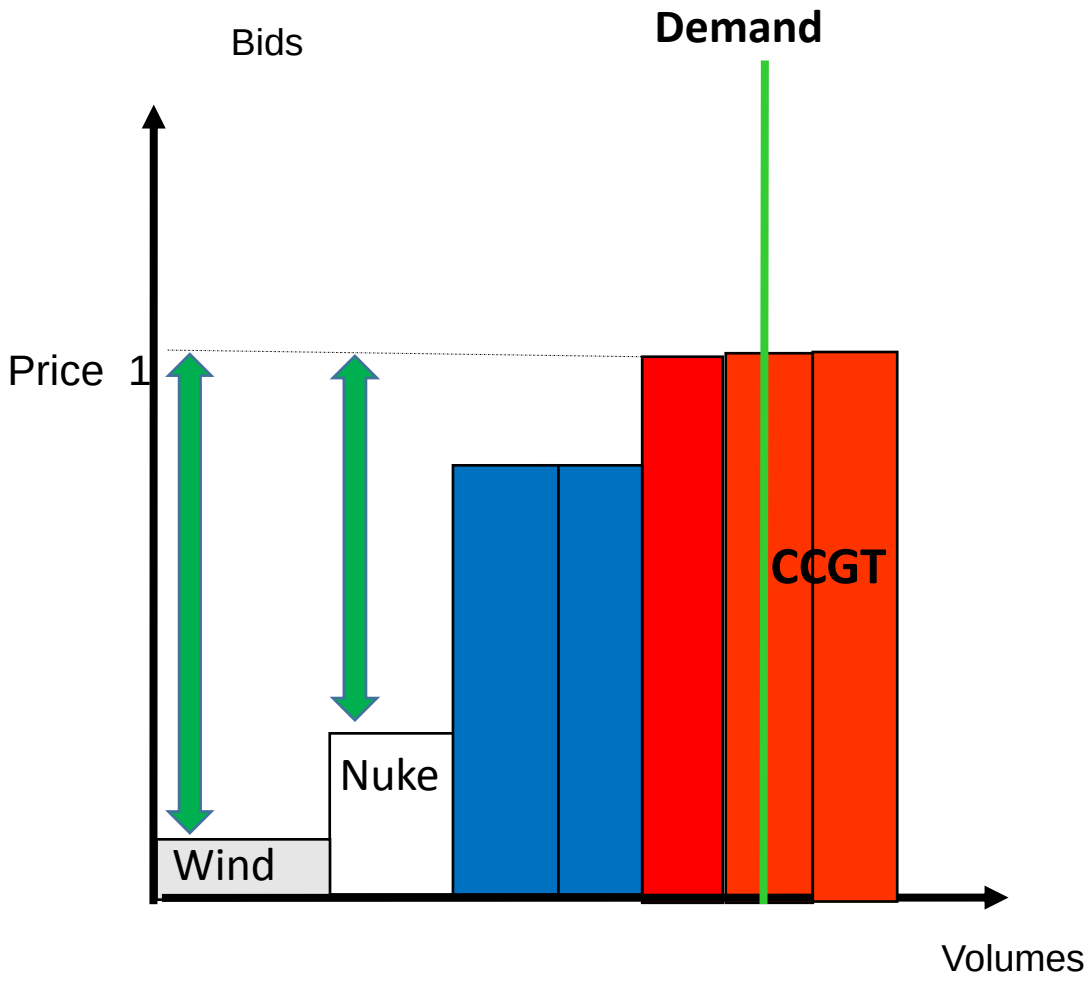
Not coverage of LCOEs by revenues on hourly markets

- **Sum of net revenues on hourly markets to recover fixed cost (to be anticipated on 10-15 y.)**
- **Low carbon technologies have larger fixed costs than fossil fuel plants**

When calculation of net present value (NPV) with carbon price

Prospect of higher surplus for low carbon plants on hourly markets

Rent of low carbon tech without carbon price



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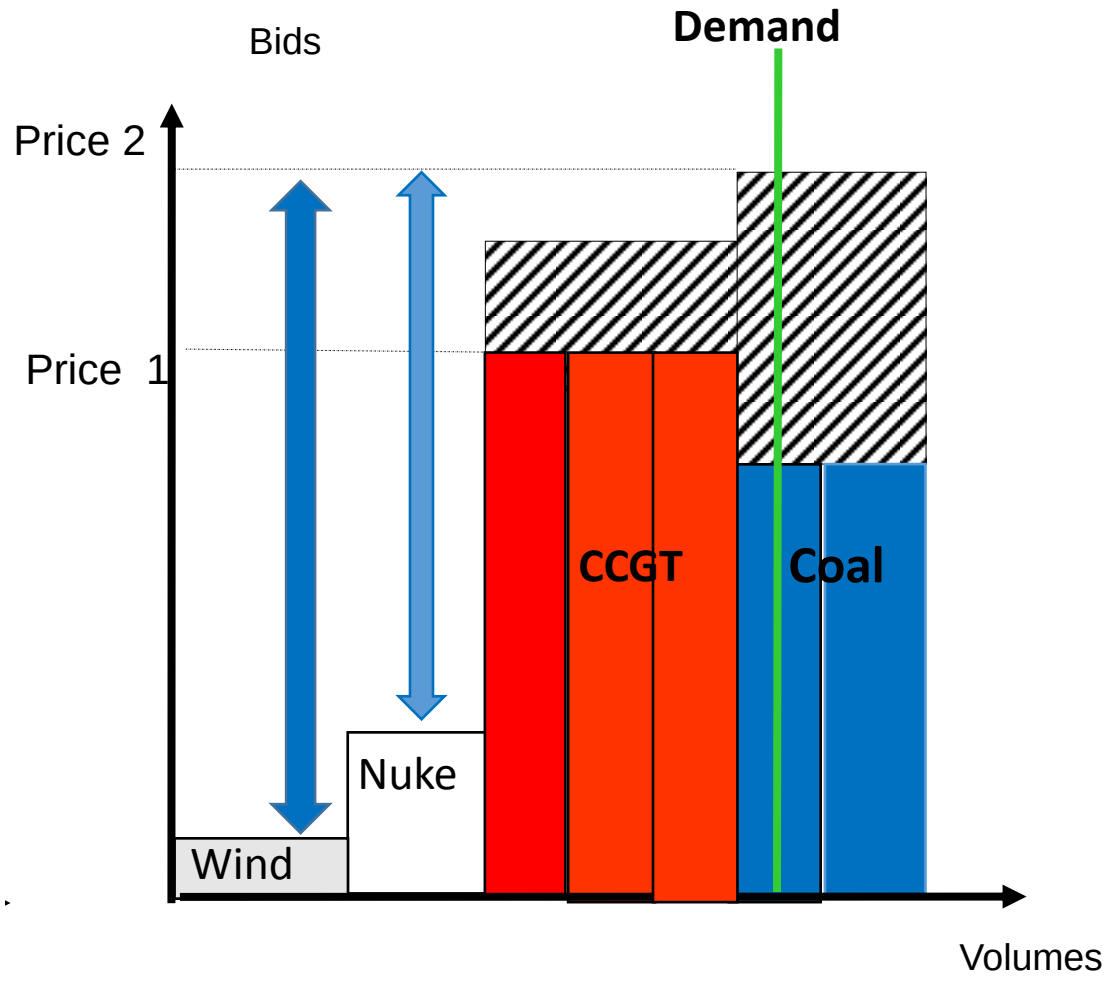
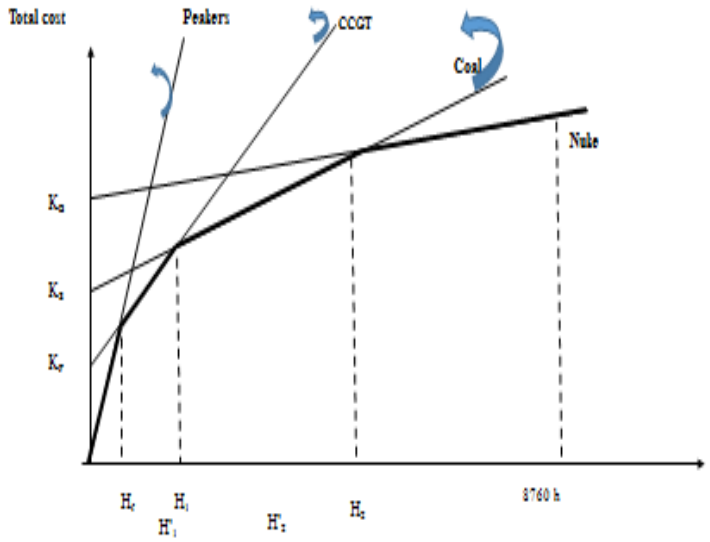
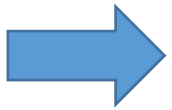
Note : issue of risk management for on electricity markets

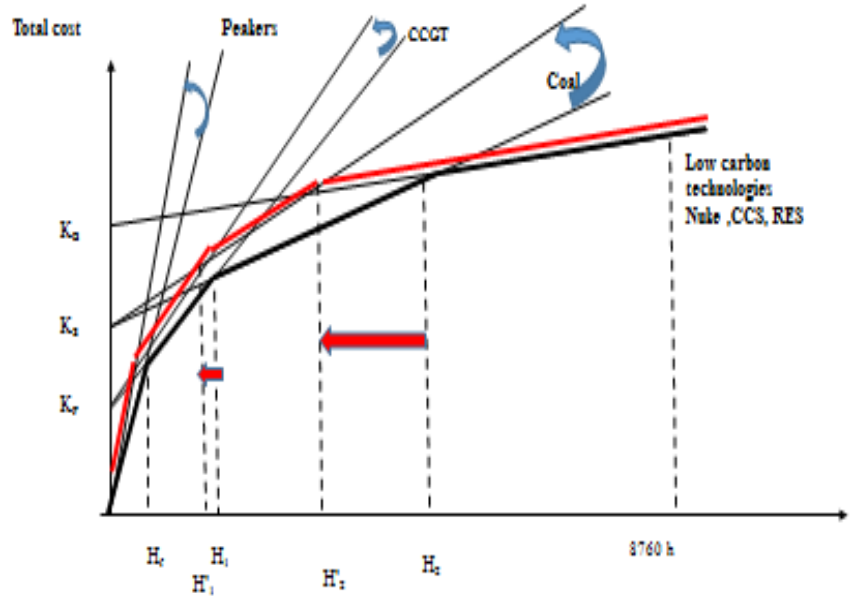
Rent of low carbon tech. with carbon price



Long term effects of carbon price on structure of the technology mix







More infra marginal rents for low carbon technologies (and for lower carbon ones CCGT)

1.3 Effects on retail price: issue of distributional effects of carbon pricing

Pass through of the increase of wholesale prices in annual average,

Increase of retail price is a legitimate signal addressed to consumers on their indirect responsibilities in carbon emissions, but it is not so simple

But distributional effects raise the issue of acceptance (lobbying of energy intensives industries) and equity (protection of small/poor consumers,)

The issue is different between the three options Taxation, Auctioned allowances, Free allowances

- Taxation and auctioned allowances: only carbon rent on existing low carbon equipment
- Free allowances: carbon rent not only for low carbon equipement but for existing fossil fuel equipment

This could be perceived as undue rent (not used to invest in low carbon equipment)

In case of free allowances, a hot issue: « undue » rent on existing emitting plants

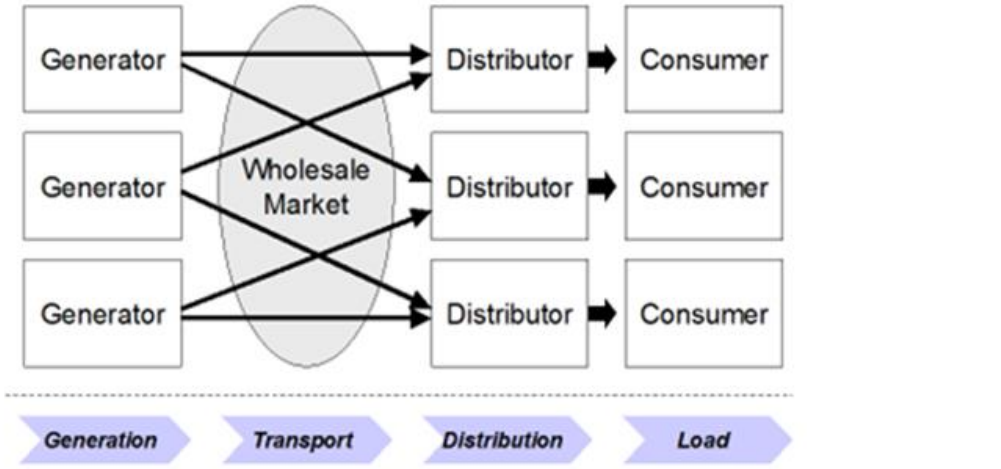
- Price bids on the market aligned not only the variable costs, but also include the market value of allowances
  - Opportunity cost is passed through in the bid price of every « fossil »competitor, and then in the hourly price
  - To note: Difference of cost pass-through between power sector and other sectors (cement , chemical, steel…) exposed to international competition with competitors w/o carbon constraints
- The answer in the EU: to skip to full auctioning in power sector in the 3rd EU-ETS phase (2013-2020)
- Another possible answer if regulated tariffs for small consumers (last resort):
  - No pass through in the reference wholesale energy price of the tariffs

What could happen in emerging countries with remaining strong regulation on wholesale and retail prices?

3. Carbon pricing in Hybrid Model (Planning + long term competition for contracts)

Model 3: Wholesale competition (with auction of long term contracts) and retail monopolies

Exemples: Brazil with central auctioning, Chili with decentralized call for tenders



Hybrid model : planning + long term competition for contracts

In the past decade, second wave of reforms in Latin America (Brazil, Chile, Colombia, Peru) to overcome market failures to invest: To get out the price setting aligned on short term marginal cost.

The core of these new schemes lies on three main rules:

- All retailers and free consumers (>2-3MW), should be 100% contracted at any time
- All contracts should be covered by “firm energy” or “firm capacity” or both.
- Some contracts could last on 15 years and more in Brazil
- Auction : Regulated retailers must acquire their energy supply contracts through auction (centralized auction in Brazil and Colombia)
  - Remaining distributors monopoly (retail prices for consumers are regulated), except for very large consumers: this allow them to contract on long term
- Minor role for the market : centralized cost-based dispatch (called “spot market”)
  - e.g.Brazil: computational model to define each week three blocks prices

Long term option contracts in Brazil : quid with an ETS?

- Generators bid not only on the capacity price ($/MW) but also on the option strike price on the energy part of the contracts ($/MWh).
- Bids are compared on the basis of the expected benefit of each project for consumers in 2-phase hybrid auction)
  - At each auctioning, the government, by means of a simulation procedure, calculates(i) the expected value of their fuel cost reimbursements (in $/year), and (ii) the expected value of the short-term transactions at the spot market (in $/year).
  - a single unit energy cost–benefit index in $/MWh of firm energy is then calculated for each technology.
  - After selection, all contracts have full indexation to fuel prices and inflation.

- So for the long term effect of carbon pricing ,
  - importance of the way the carbon price expectations (including its volatility) is taken into account in the calculation of the expected value of their fuel costs reimbursements in the selection process by the auctioning
  - Importance of a full indexation to the ETS price beside fuel price and inflation
- Importance to adjust existing long term contracts

Conditions of effectiveness of an ETS price

- Short term effect: No need of change in the economic dispatching process
  - In Brazil computation of short term price should include carbon price in the variable cost of the fossil fuel plants

- Long term and structural effects

  ETS price is supposed to incite to invest in low carbon technologies

  Their economic position will be reinforced in the auctioning if technology neutral

  But problem for fossil fuel technologies
  - They will have lower economic value but they are needed beside RES and Hydro plants (higher frequency of drought)
  - The auctioneers with fossil projects have to anticipate the change in their variable costs.
  - Recovery of fixed costs but under the condition that the variable costs (fuel and carbon) are recovered
  - The structure of the contracts should be flexible to allow permanent alignement of prices on complete costs (pass through of carbon price variations in the indexation of strike price ?)
  - Specific auctioning for fossil fuel technologies

Distributional effects of carbon pricing in the hybrid model

On the side of existing producers entered with former contracts

- if carbon pricing is introduced, it should be necessary to readjust :
  - the indexation formula in existing contracts ;
  - or in the case of Brazil, in the energy part of the contracts, the strike price of the energy option contract

  If no re-adjustment of existing long term contracts, the risk is that a generator will close its equipment if it could not cover its variable costs when carbon price increases

On the side of consumers

Retail price regulations could not guarantee the pass through of wholesale price change in the regulated tarifs

- Issue of rent if free allowances for the emitting plants
- Increase of the wholesale price in relation to the technology mix (number of hours when a fossil plant is marginal in the dispatch)
  - In systems with hydro (75% Brazil; 60/65% Colombia, 40% Chili), carbon pricing creates rent on hydro producers during hours when fossil plants are marginal (with and w/o free allowances)
  - It could be a problem if fossil plants are marginal during almost all the year (rent on the energy market + competition issue)

  Answer: tax on hydro rent

To sum up

- **Short term effectiveness** : Importance of the power exchange/economic dispatching
- **Long term issues** : effectiveness of long term contracts

  but adaptation of the structure of the contracts (inclusion of carbon prices in the indexation formula) and adaptation of the criteria of the auctioning
- **Distributive issue** :
  - The issue of carbon cost-passthrough if free allowances
  - The issue of rent on existing hydro plants

In fact effectiveness of the system w/o carbon pricing

Long term contracts secure de facto high upfront cost technologies , as low carbon and RES ones.

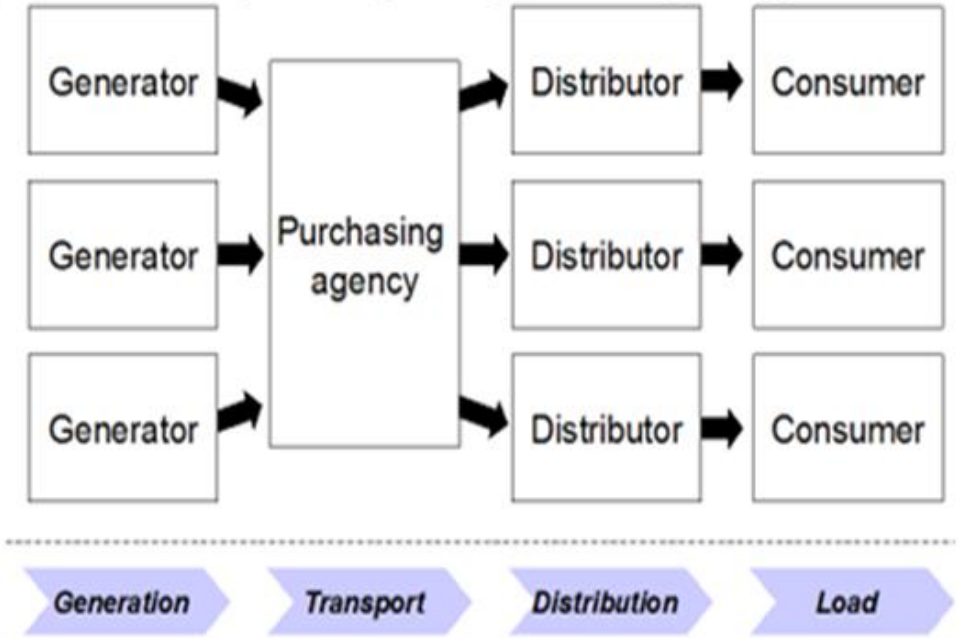
Hydro and Windpower projects have been selected in techno neutral auctioning in Brazil without carbon pricing

Fossil fuel plants should be in a specific auctioning

3. Single buyer
The need of a consistent electricity market design if carbon pricing

Model 2: Purchasing agency (single buyer) for regulated distriutors/retailers at regional or national level

Exemple: China with public regional grids as single buyers



Single Buyer Model (including state-owned utility + PPAs Model)

Many countries keep vertical integration combined with IPPs, e.g. India, Indonesia, Mexico, Malaysia, Pakistan, Philippines, South Africa , Vietnam , etc;

Features in common:

Planning is run by a central agency—usually the utility—who forecasts demand

Procurement of new generation is usually run by the vertically integrated utility (or the single buyer when it is specific entity, as the grid companies (China) or a special agency (Ontario)

Electricity supply outside the utility's internal contracts is governed by long term Power Purchase Agreements (PPA)

Typical structure of Power Purchase Agreements

Long term contracts for the life of the asset (25 to >40 years) with a typical allocation of risk:

PPAs based on two types of payments:

- Capacity charges: cover the fixed costs of the plant, including all capital costs and fixed O&M costs.
- Energy charges: cover the variable costs of the plant including fuel costs and all variable O&M costs.

Take or Pay provisions: very protective. Could make sense because IPP has no control over the dispatch

Inflation and foreign exchange , fuel price risks are transferred onto the buyer by indexation fromula and escalation provisions

Dispatch of the independent plants is not common with the dispatch of the utility single buyer

Constraints with the Take or pay contract

Effects of carbon pricing in Single buyer model (or State owned +IPP model)

- **Short term effectiveness** : IPPs are not in the economic dispatch by the single buyer (to except South Korea)

- **Long term effectiveness**:
  - Need of more flexible PPAs with full indexation of ETS price
  - Planning + PPAs tendering could favor low carbon investment because the tendering is techno-specific

    Important in countries where the RES-E and hydro are competitive w/o carbon price as in South Africa

- **Distributional effects** :
  - **Existing IPPs**: Need **to adapt existing PPAs** to introduce carbon price in the formula
  - Problem for the **Single Buyers** if the carbon ETS price change is not passed through in the wholesale and retail tariffs : **risk of squeeze**
  - **Consumers**: The issue of carbon cost passthrough if free allowances ti the incumbent and the existing IPPs

The Chinese case : a very specific Single Buyer model

The goal: easing financing and entries face to important shortages

Adoption of a more decentralised model

- many generators, separation of grids and distributors (regulated tatiff
- Regional single buyers (regional grids) with rigidly administered PPAs
  - initially fixed price/ no indexation formula,
  - fixed annual production planning
  - **absence of economic dispatching (equal share dispatch + special regime for old coal plants)**
- Regulation with no cost pass through in regulated wholesale price when change of fuel costs
  - When coal price increased after semi-liberalization , threat of numerous closures and risk of outages
  - Just a yearly adjustment if coal price change

Chinese case

What if a national ETS is introduced, covering the power sector (90% free allowances) ?

- Short term effects

  No economic dispatching, so no advantage for the most efficient coal plants (supercritical coal plants) to produce more, nor for the CCGTs

  Problem of introduction of variable ETS price: necessity to a flexible and reactive indexed price formula (coal price, carbon price)

- Long term effects

  No playing field between generation technologies because of the fixed price setting and the annual production planning

  limit revenues prospects +regulatory risks

  If free allowances and no cost passthrough, reduction of incentives to invest in low carbon technologies (Nuke, CCS, hydro, large RES-E) or very efficient coal plants

- Short term and long term effects of exemption of small and medium size coal plants (70 GW to 200 GW concerned),

To sum up

- Problem related to the **absence of an economic dispatching** (via a power exchange or a dispatch market center)
- Problem related to the **rigidity of price adaptation (no adaptation to fuel price, and so to carbon price) in the pseudo-PPAs**
- Problem with exemptions of inefficient plants
- **Redistributive effects** : Discretionay nature of regulation for the cost pass-through

Carbon taxation could be a better solution

Chinese case : Some solutions

On the carbon pricing tool: taxation could be a better solution than ETS in the power system (N. Stern and F. Green, 2015)

- Option 1 Accelerating the reform of the power sector
  - An hourly dispatch based on a bid-price market or eventually a cost-based dispatch (see Latin america dispatchings),
  - Redefinition of PPAs with transparent and cost reflective indexation clause (
  - the definition of retail tariffs in narrow relation to the wholesale prices.

Option 2; Replacing the “equal share” dispatch by an energy minimizing dispatch at the national level

But at the end of the day

- Planning and programming are the fundaments of the Chinese power sector
- Dirigism in matter of RES programs (based on FIT) (300 GW in 2030) , Nuclear (150 Gwin 2030), Hydro (restrictions), …. And old coal plants closures

5. Conclusions n° 1

Carbon pricing have different effects on carbon reduction and on electricity pricing , depending on the organisational model of power sector

- **Short term reduction effect**: need of an economic dispatching either by the spot market or by the dispatcher coordination
- **Long term effects :**
  - For low carbon technologies :need of stability of long term revenues for investors :
    - long term contracts « à la brésilienne » or smart flexible PPAs ideal for that goal
  - Problem of needed fossil fuel plants: decision of planner and specific auctioning of long term contracts
- **Distributional effects**: mind the issues of free allowances rents and hydro rents if market dispatch

  tariffs regulation: regulators will skip rents

Choice of the carbon pricing tool:

- Carbon tax better adapted to strongly regulated system (quite few players in ETS-covered industries, in particular when one state-owned utility (case of South Africa)
- Clearer price signal

Limitation on carbon pricing effectiveness when uncomplete market-based reform

Conclusion n°1

- But is it useful to improve market design to get short-term marginal cost pricing in view of the decarbonation?

Indeed with the Hybrid Model as well as the Single Buyer model: Positive advantages of planning and long term contracts for decarbonation

But mind some potential drawbacks:

- possible overshooting of capacity development, or else technology overshooting if specific technology call for tenders
- in some countries, preference for fossil fuel plants (less capital resources, more attractiveness),
- difficulties for smaller companies to compete with large companies or incumbent on RES projects (need of specific RES framework to implement)

Conclusion 2: Inversion of the sense of lessons

From emerging economies' systems to **mature market-based systems** of EU and OECD countries

Even with credible and significant price signal, carbon pricing not very effective

How trigger low carbon investmentswith electricity markets rooted in the principle of SRMC pricing ?

- Issue of the high upfront cost recovery and anticipation of infra marginal rents on the pay out time
- After evolution of the generation mix toward capital intensive technologies, merit order effects and low energy market prices:
  - Amplification of the problem with variable RES-E development by out-of- market incentives, whatever their design (FIP versus FIP, etc.)

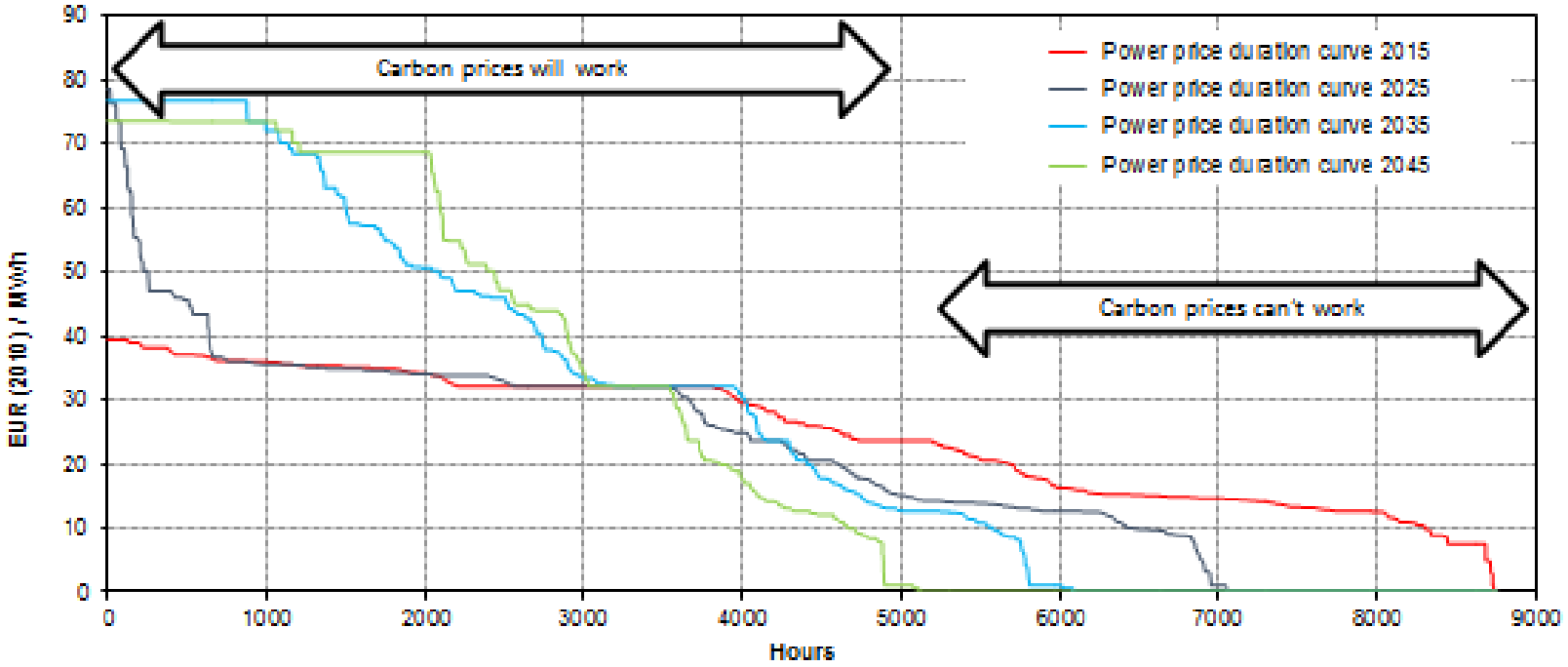
Current markets need to evolve towards hybrid market : when?

Conclusion 2: Inversion of the sense of lessons

From **emerging economies** to **mature market-based systems** **of EU and OECD countries**

A first observation

Intrinsic limits of current power market after endogenous or exogenous entries of low carbon technologies (among which RES)



When zero SRMC or low SRMC technologies are increasingly marginal