Lecture - 1

Introduction to Energy Economics and Policy

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Outline

- Energy Economics
- Energy Policy

Energy Economics

The energy sector is complex because of number of factors:

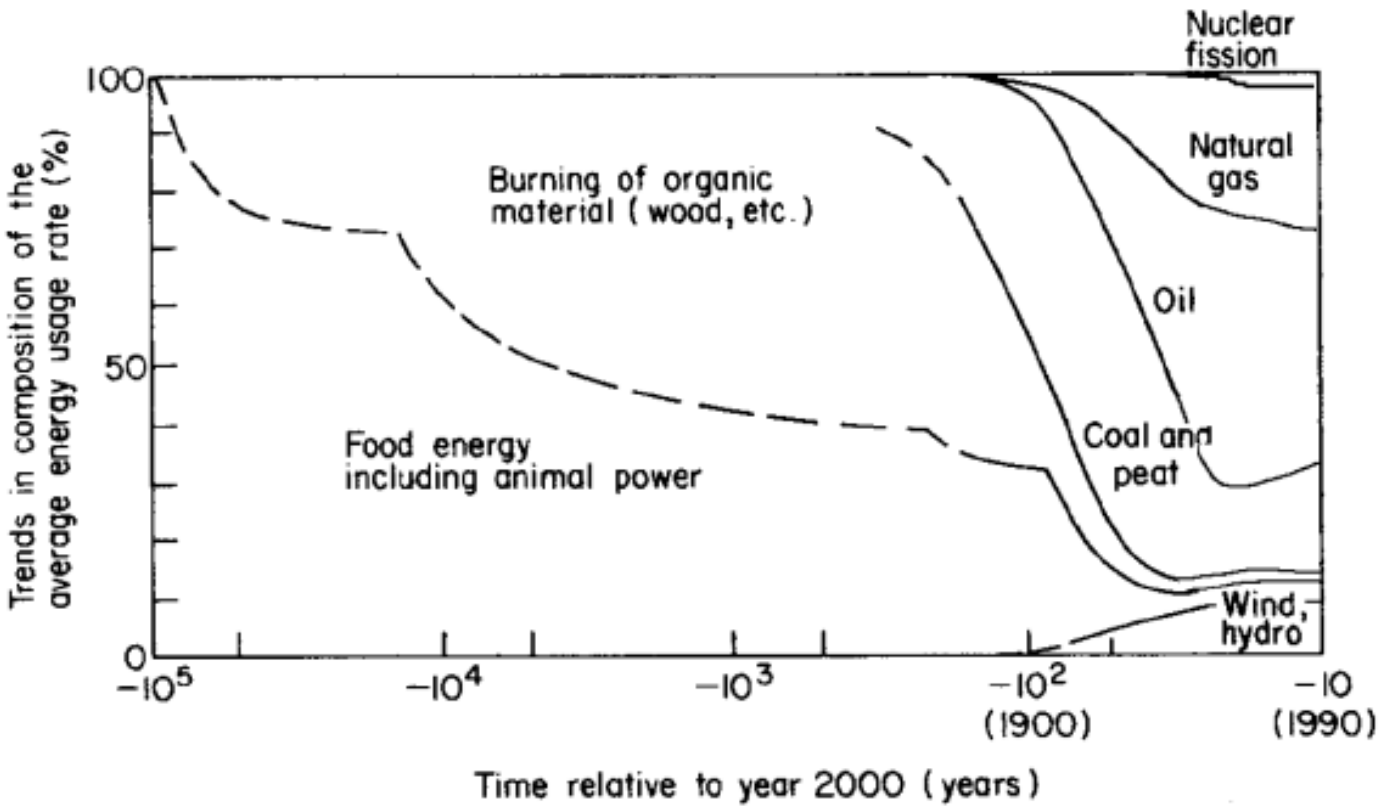
- The constituent industries tend to be highly technical in nature, requiring some understanding of the underlying processes and techniques for a good grasp of the economic issues,
- Each industry of the sector has its own specific features which require special attention,
- Energy being an ingredient for any economic activity, its availability or lack of it affects the society and consequently, there are greater societal concerns and influences affecting the sector,
- The sector is influenced by interactions at different levels (international, regional, national and even local), most of which go beyond the subject of one discipline.

Source: S. Bhattacharyya

What is Energy economics?

- Energy economics or more precisely the economics of energy is a branch of applied economics where economic and to analyze them logically and systematically to develop a well-informed understanding of the issues.
- Energy economics is the field that studies human utilization of energy resources and energy commodities and the consequences of that utilization.
- Energy economics involved energy resources and energy commodities and includes forces motivating firms and consumers to supply, convert, transport, use energy resources, and to dispose of residuals; market structures and regulatory structures; distributional and environmental consequences; economically efficient use.

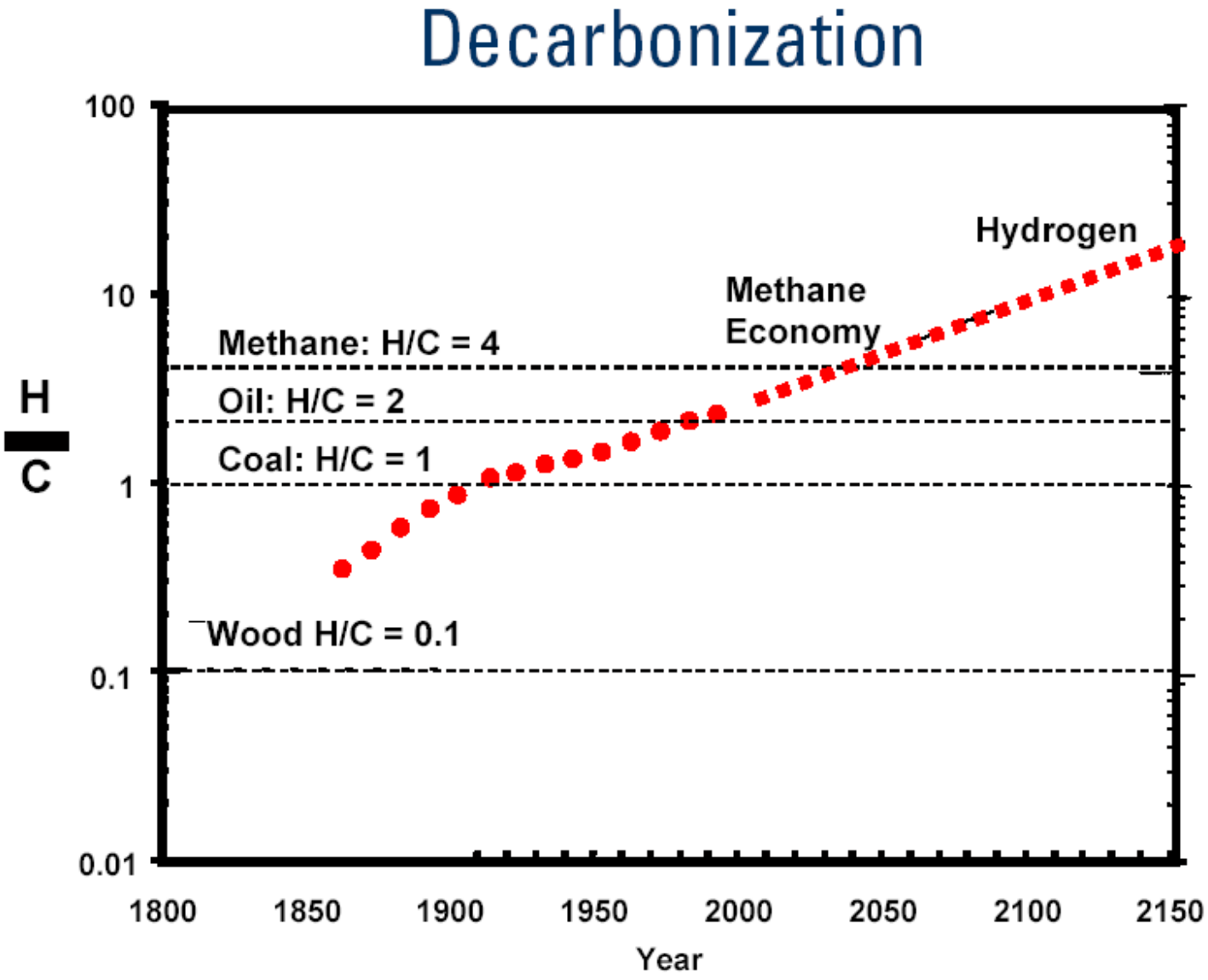
History energy transition



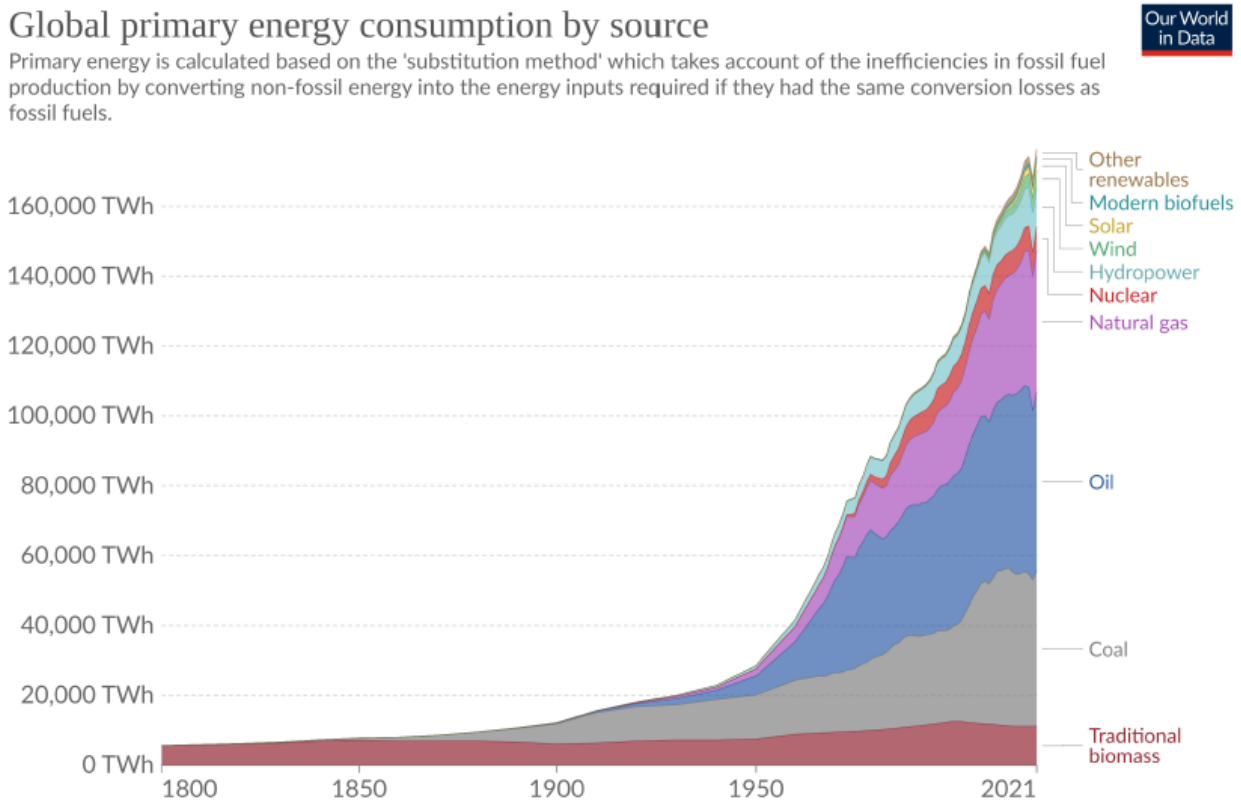
Energy transitions from muscle to biomass to coal to oil and gas, next: low-carbon electricity?

Source: Sorensen

Wood → Coal → Oil → Gas → renewables, low carbon electricity

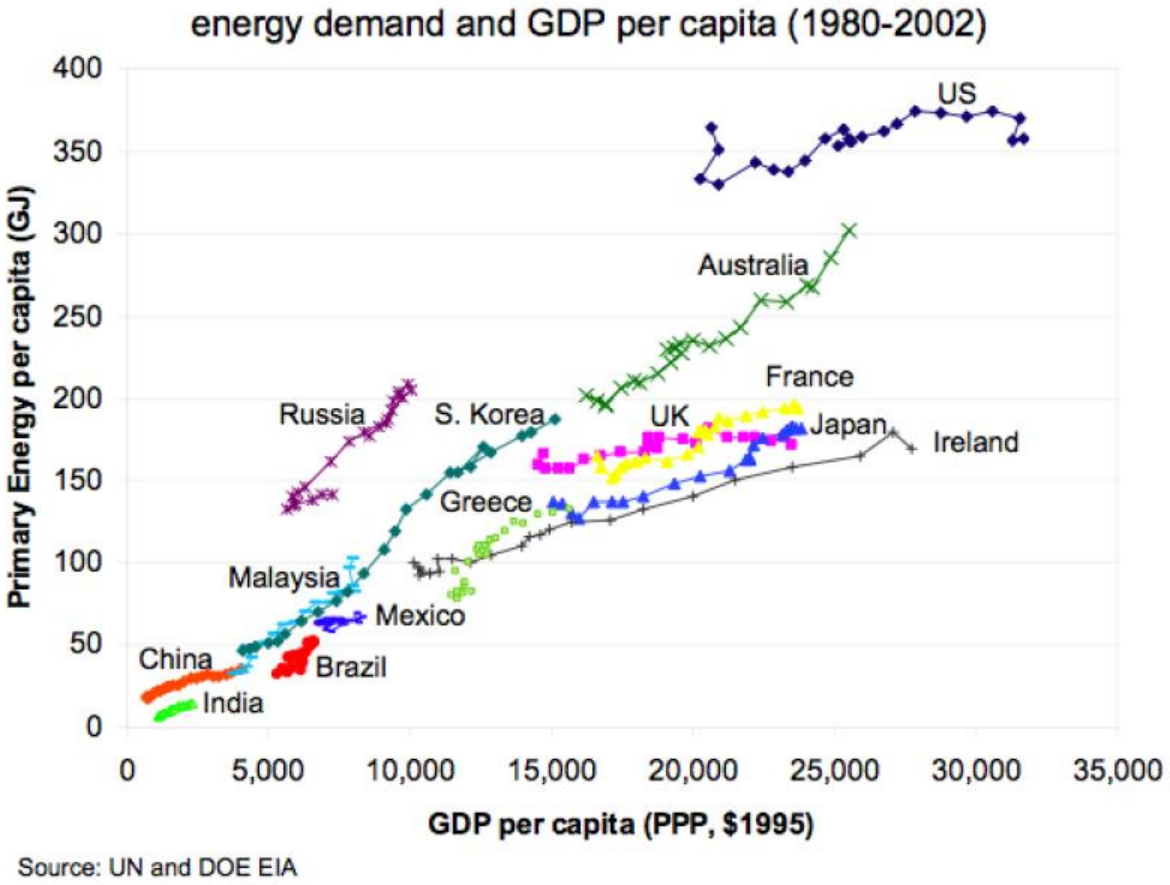


Primary energy growth



Extraordinary growth in primary energy consumption since 1950s, much in oil and gas.

Economic development and energy use



Energy demand versus GDP over time for selected countries.

What makes energy economics different from regular economics?

The unique features of energy are numerous:

- Essential for modern life: for farming, cooking, lighting, comfort in buildings (heating and cooling), communication, mobility, production of most goods. This makes it a political concern.
- Essential to all economic activity. Cf. negative economic consequences of electricity blackouts in South Africa, European gas crisis of 2021-202?.
- Reserves of fossil fuels and production capacity/minerals for renewables & storage are concentrated in a few countries. Geopolitics!
- Large externalities: most greenhouse gas emissions come from use of fossil fuels in energy, leads to climate breakdown; air pollution leads to widespread health impacts; for nuclear in meltdown and waste risk; for renewables in landscape impact.
- High potential for innovation and cost reduction: wind, solar, batteries, electrolysers

What makes energy economics different from regular economics?

- Energy is abundant in nature, but mostly not immediately available for doing useful work.
- Infrastructure (transmission, generators) requires long periods of planning, investment and operation. Leads to slow change - inertia!
- In many markets there are monopoly structures, which are resistant to market solutions and need regulation (e.g. transmission networks, but also vertically-integrated utilities in some regions).
- Infrastructure property rights (e.g. underground, hydro) are sometimes with public rather than private sector.
- Some risks are diffuse and widespread (nuclear, hydro, landscape impact of wind).

Two Level of Economics

Micro Economics

- The branch of economics that examines the functioning of individual industries and the behavior of individual decision-making units—that is, business firms and households.
- Scarcity, Ideal Market Failures, Consumer Choices, Monopoly

Macro Economics

- The branch of economics that examines the economic behavior of aggregates—income, employment, output, and so on—on a national scale.
- Growth, Employment, Price Stability, In-equality, Recessions, Deficits, Fiscal and Monetary Policies, Green Economy

Microeconomics looks at the individual unit—the household, the firm, the industry.
It sees and examines the "trees."
Macroeconomics looks at the whole, the aggregate. It sees and analyzes the "forest."

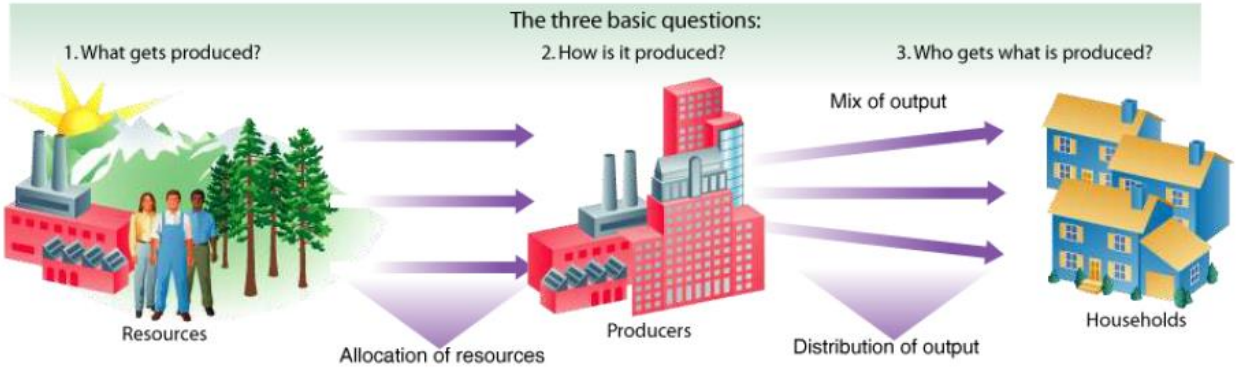
Examples of Microeconomic and Macroeconomic Concerns

Divisions of Economics	Production	Prices	Income	Employment
Microeconomics	*Production/output in individual industries and businesses*	*Price of individual goods and services*	*Distribution of income and wealth*	*Employment by individual businesses and industries*
	How much steel How much office space How many cars	Price of medical care Price of gasoline Food prices Apartment rents	Wages in the auto industry Minimum wage Executive salaries Poverty	Jobs in the steel industry Number of employees in a firm Number of accountants
Macroeconomics	*National production/output*	*Aggregate price level*	*National income*	*Employment and unemployment in the economy*
	Total industrial output Gross domestic product Growth of output	Consumer prices Producer prices Rate of inflation	Total wages and salaries Total corporate profits	Total number of jobs Unemployment rate

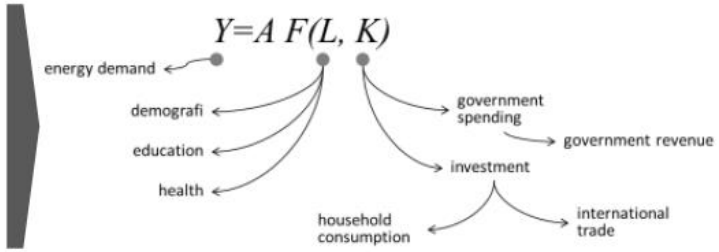
Economics can be seen as a study of Flow of Goods and Capital

- ***What Gets Produced, How is it Produced, Who Gets the Products***

Every society has some system or process that transforms its scarce resources into useful goods and services. In doing so, it must decide what gets produced, how it is produced, and to whom it is distributed. The primary resources that must be allocated are land, labor, and capital.



Cobb Douglas Production Function



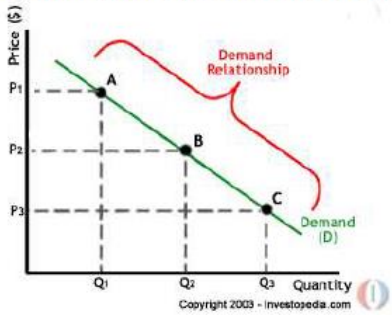
Economics is about Resources Management

The concepts of constrained choice and scarcity are central to the discipline of economics

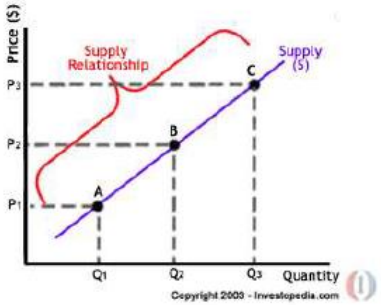
- Opportunity Cost: The best alternative that we give up, when we make a choice or decision
  - Using a day at the beach as an example, what is the opportunity cost of leisure? The opportunity cost of leisure at the beach is the value of the things that you could have produced during the time you were at the beach. For example, you could have used the time to work and earn some money.
- Choice, if rational, is about maiximizing value gained from economics activities (also named as "Utility")
  - Does human choice ever rational? ;)
- Theory of comparative advantage: a theory that specialization and free trade will benefit all trading parties, even those that may be "absolutely" more efficient producers.
  - **absolute advantage** A producer has an absolute advantage over another in the production of a good or service if he or she can produce that product using fewer resources
  - **comparative advantage** A producer has a comparative advantage over another in the production of a good or service if he or she can produce that product at a lower opportunity cost.
- In order to have choice, we need free market, that multiple sellers must sell to multiple buyers
- **laissez-faire economy**. Literally from the French: "allow [them] to do." An economy in which individual people and firms pursue their own self-interest without any central direction or regulation.

Energy Markets and Principles of Energy Pricing

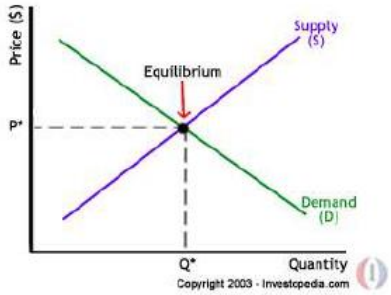
Basic Competitive Market: the theoretical world of perfect competition: consumers maximize their utility subject to their budget constraints and producers maximize their profits subject to the constraints of production possibilities.

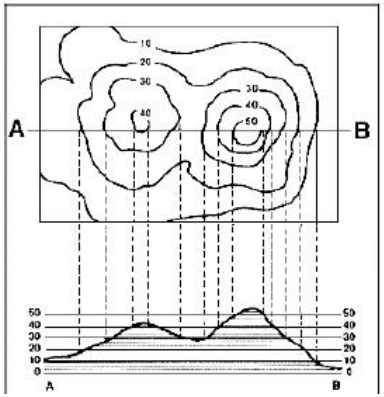


The reduction price will increase demand quantity at certain line



The increased of price will increase the supply quantity



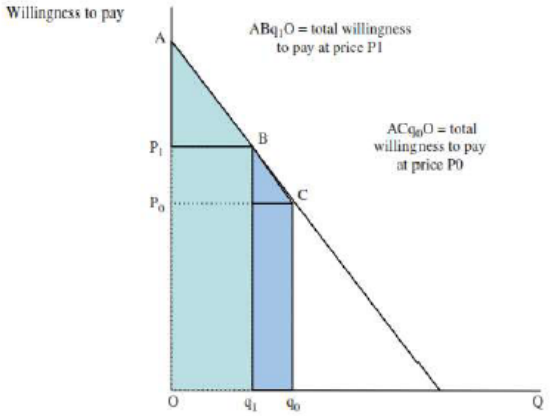


When shifting, try to imagine that the curve shifts is like a hill that has different height

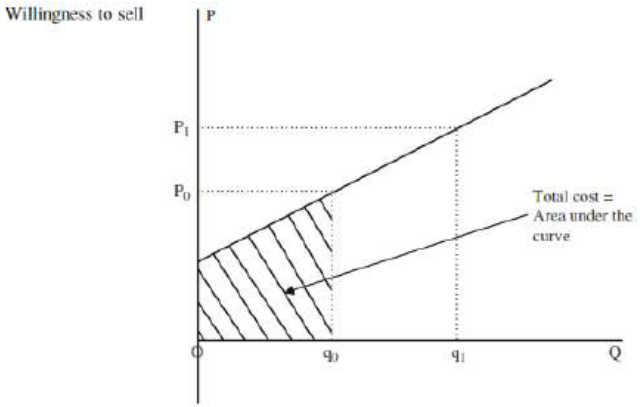
Energy Markets and Principles of Energy Pricing

Basic Competitive Market

- There are numerous consumers and producers trying to transact in the marketplace (no monopoly). In a competitive market condition, all agents are price takers, and any agent has no market power. Generally, the demand for a good reduces as prices rise (i.e. inverse relationship with price) and vice versa.



Consumers satisfy their utility (or preferences) by consuming a good. As utility is not observable, an alternative parameter for measurement of their satisfaction is **the willingness to pay or accept** to **move** from a situation to another.



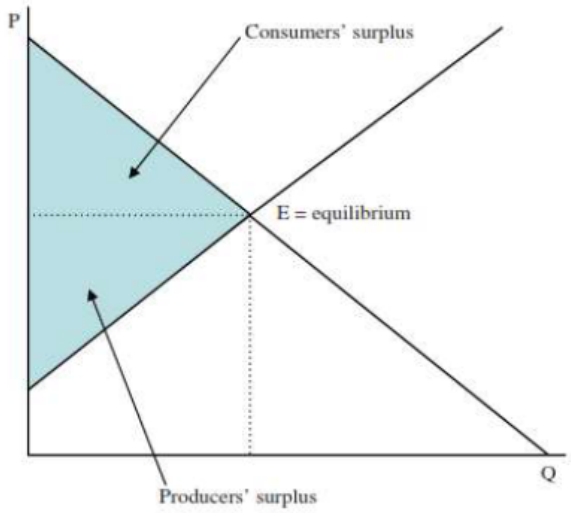
The sellers, on the other hand, incur cost for producing the goods sold, and as long as the costs are recovered, they may be **willing to sell** for any given price. However, even at that price, some sellers will receive more benefits due to low-cost production, while others will break even. Therefore, the benefits accrued to the producers are known as "producer surplus".

Competitive Equilibrium

- ***Basic Competitive Market***

- Competition forces **sellers to charge no more** than their rivals.
- If one seller charges more than the market clearing price, consumers will go to others offering the same good at a lower price. If someone charges less than the market price, the demand will outweigh the supply, forcing a return to the market price.
- Individual buyers and sellers cannot affect the price. Buyers and sellers react to changes in the market price. At lower prices, some sellers will leave the market while more consumers enter it. Similarly, at higher prices more sellers are willing to offer their goods while there will be fewer consumers. The participation in the market is voluntarily and consumers or sellers are free to enter or leave the market in a perfectly competitive case. Price is equal to the **marginal cost** of the last supplier.
- However, certain basic conditions have to be satisfied to obtain such efficiency outcomes: existence of freely competitive markets, perfect and costless flow of information and knowledge, smooth transferability of resources and absence of externalities.
- Clearly, most of these requirements are not satisfied by the today's energy market. In addition, the energy sector is marked by certain specific characteristics such as indivisibility of capital, tradability of some products and depletion of some resources.

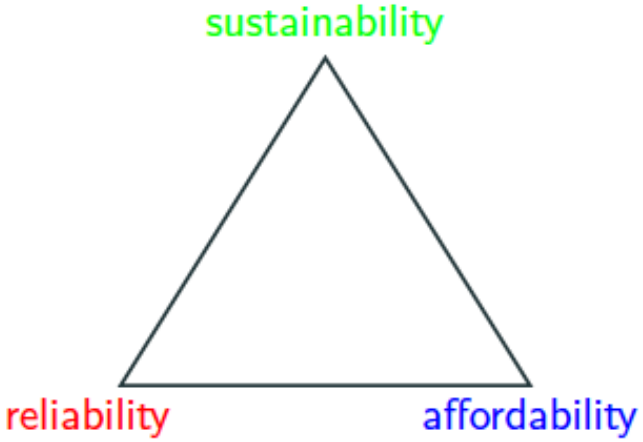
Fig. 12.3 Competitive equilibrium



Energy Policy

Guidelines for Energy Policy: Trilemma

What should a well-functioning energy system look like? We design with respect to three goals:



- **Sustainability**: Respect environmental constraints (greenhouse gases, air quality, preservation of wildlife), as well as social and political constraints (public acceptance of transmission lines, onshore wind, nuclear power)
- **Reliability**: Ensure energy services are delivered whenever needed, even when the wind isn't blowing and the sun isn't shining, and even when components fail
- **Affordability**: Deliver energy at a reasonable cost

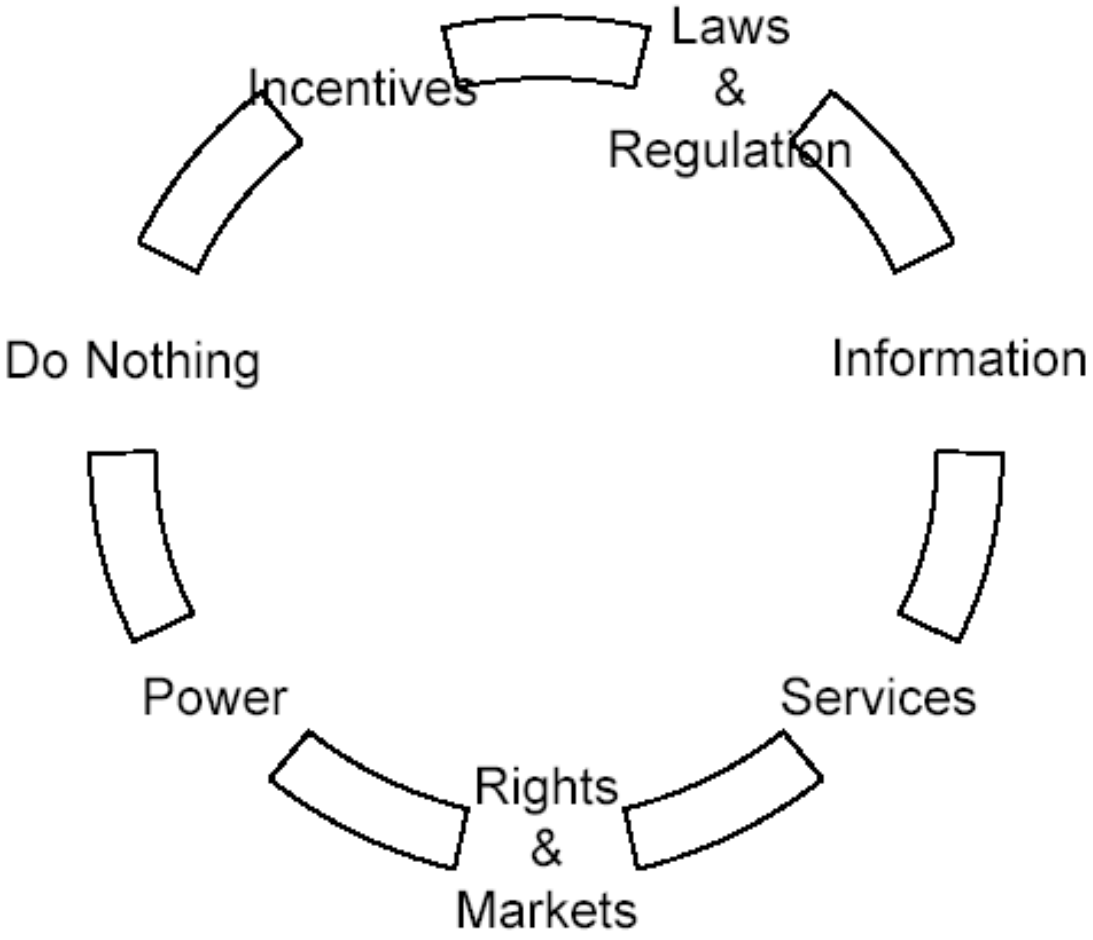
Some of these policy targets can come into **conflict** - an **energy trilemma**.

Objective of Energy Policy

- must be develop to meet the many interrelated and often conflicting overall national objectives as effectively as possible;

- promote economic development and growth, increase energy security, and improve the environment.

Tools of government



Why Regulate?

- Avoid monopoly
- Regulation: exclusive teritories, setting rate/tariff etc
- Who ragulates: Regulatory Commission or Gov.
- Regulatory process: rolemaking, rate cases, certificate cases, service standard, complaint cases

What is energy markets regulatory system?

- The energy markets regulatory system comprises the institutions and markets involved in the production, supply and consumption of energy and related services. It includes regulatory and non-regulatory measures supporting policy objectives including: reliability and security, competition, efficiency, access and affordability.
- The energy markets regulatory system includes the legislation, policy, rules and regulations for:
  - ✓ Electricity: generation, storage, transmission, distribution and retailing.
  - ✓ Gas: production, storage, transmission, distribution and retailing of natural gas and LPG.
  - ✓ Energy efficiency: provision of energy efficiency product standards and information for energy consumers.
  - ✓ Liquid fuel markets: importation, production, storage, distribution and retailing of refined oil products and other liquid fuel.

Why the energy markets system requires regulation

Natural monopolies	Economic regulation of electricity and natural gas network services with natural monopoly characteristics is warranted to prevent excessive prices and inefficiencies. Economic regulation seeks outcomes consistent with those in competitive markets, by promoting efficient allocation of costs and setting prices at a level that limits excessive profits but encourages efficiency improvements and appropriate investment.
Fuel quality	The chemical composition and performance of petrol is standardised and regulated for the protection of consumers and the environment. A consumer cannot determine the quality of the fuel before purchase (and in many cases, even after purchase), so Government regulation serves both to ensure the fitness of the fuel and to provide a signal of that fitness to consumers.
Gas emergency response	Arrangements to maintain safe pressures in gas transmission pipelines following an unexpected disruption (e.g. a leaking pipe) are regulated because prompt centralised decision-making is required to avoid free-riding and hold-out behaviour.
Common quality of electricity supply	Services that determine the voltage, frequency, and reliability attributes of electricity supply are a necessary part of the electricty system (i.e. are a public good that needs to be paid for). These services require regulation to ensure the services are provided, and to prevent free-riding or hold-out behaviour by market participants.
Information	Competition is strengthened when consumers have access to trusted information and tools to help them make informed decisions. Regulation can be used to reduce information barriers, and re-balance any information asymmetry between suppliers and consumers.

Energy regulation

Three basic principles

- independence,
- transparency, and
- investor and consumer protection.

Regulator tools and resources

- laws,
- financial resources, and
- high quality staff.

Functions of energy regulators :

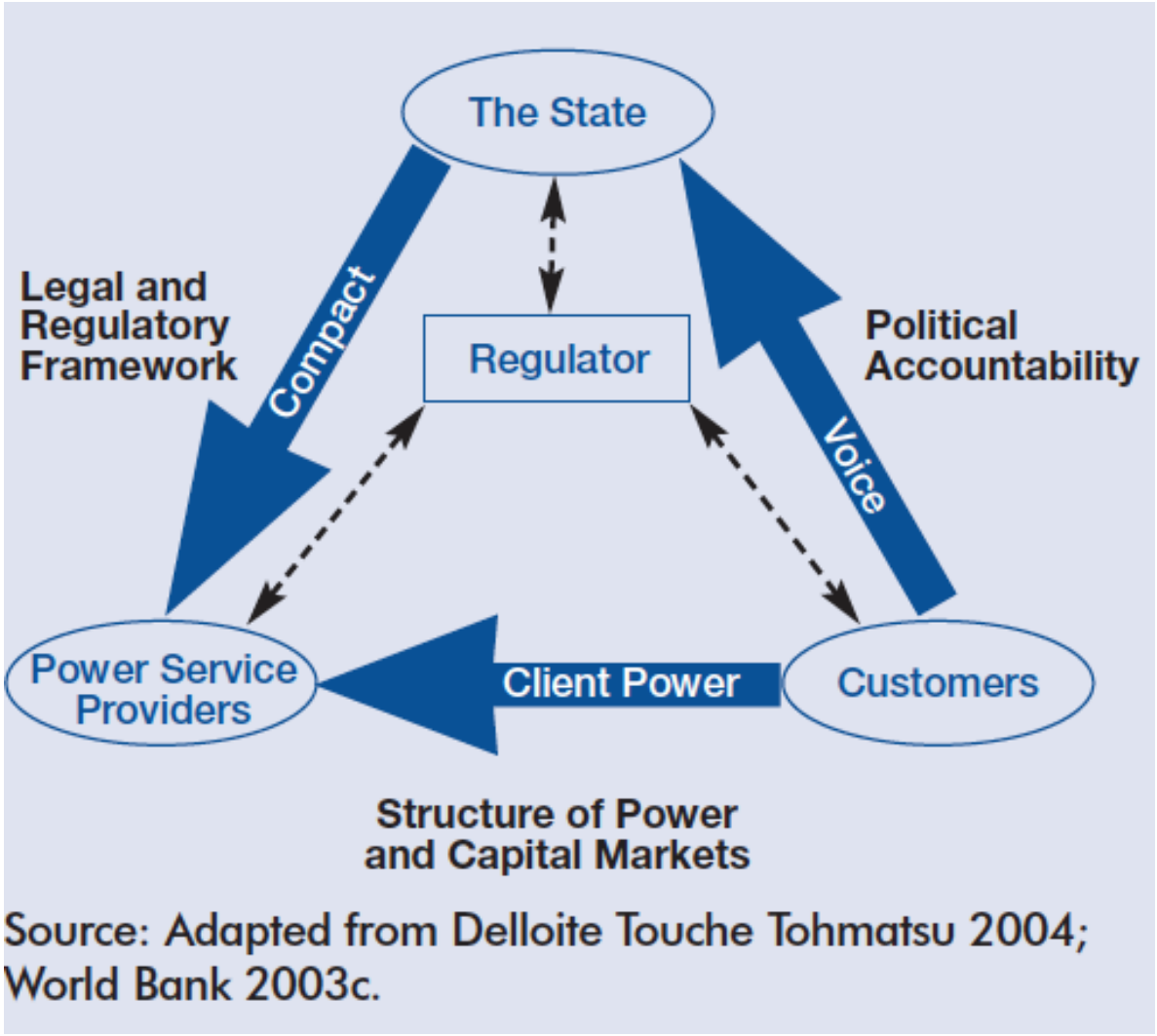
- to monitor competition in the energy market,
- to assist in the implementation and development of national and international energy policy, and
- to assist in the commercial development of energy sectors, particularly with regard to deregulation and wholesale markets.
- policy implementer,
- policeman,
- watchdog,
- instrument of industry accountability,
- communicator, and
- international policy integrator.

Source: Andreas Poullikkas, 2016

Players in energy businesses

- **Upstream oil and gas production.** This is the extraction of oil and gas out of the ground. Energy UK does not represent these activities.
- **Electricity generation.** Our electricity is generated using a range of fuel types at power plants including gas, wind, solar, nuclear, tidal, biomass. Learn more about electricity generation.
- **System operation.** The System Operator manages the actions happening across the energy system, including managing the many balancing markets to ensure system stability. Learn more about how the system works.
- **Transporting energy.** Gas and Electricity Transmission Network Owners move energy via pipes or wires for long distances around the country at high voltages. Electricity Distribution Network Operators (DNOs) and Gas Distribution Networks (GDNs) take energy from the transmission network and deliver it to homes and businesses. Energy UK does not represent DNOs or GDNs. Learn more about the energy networks.
- **Retail suppliers.** Retail suppliers supply electricity and gas to homes and businesses, and are responsible for sending bills and dealing with customer service inquiries, as well as delivering Government schemes including ECO and Warm Homes Discount. More about the energy retail market.

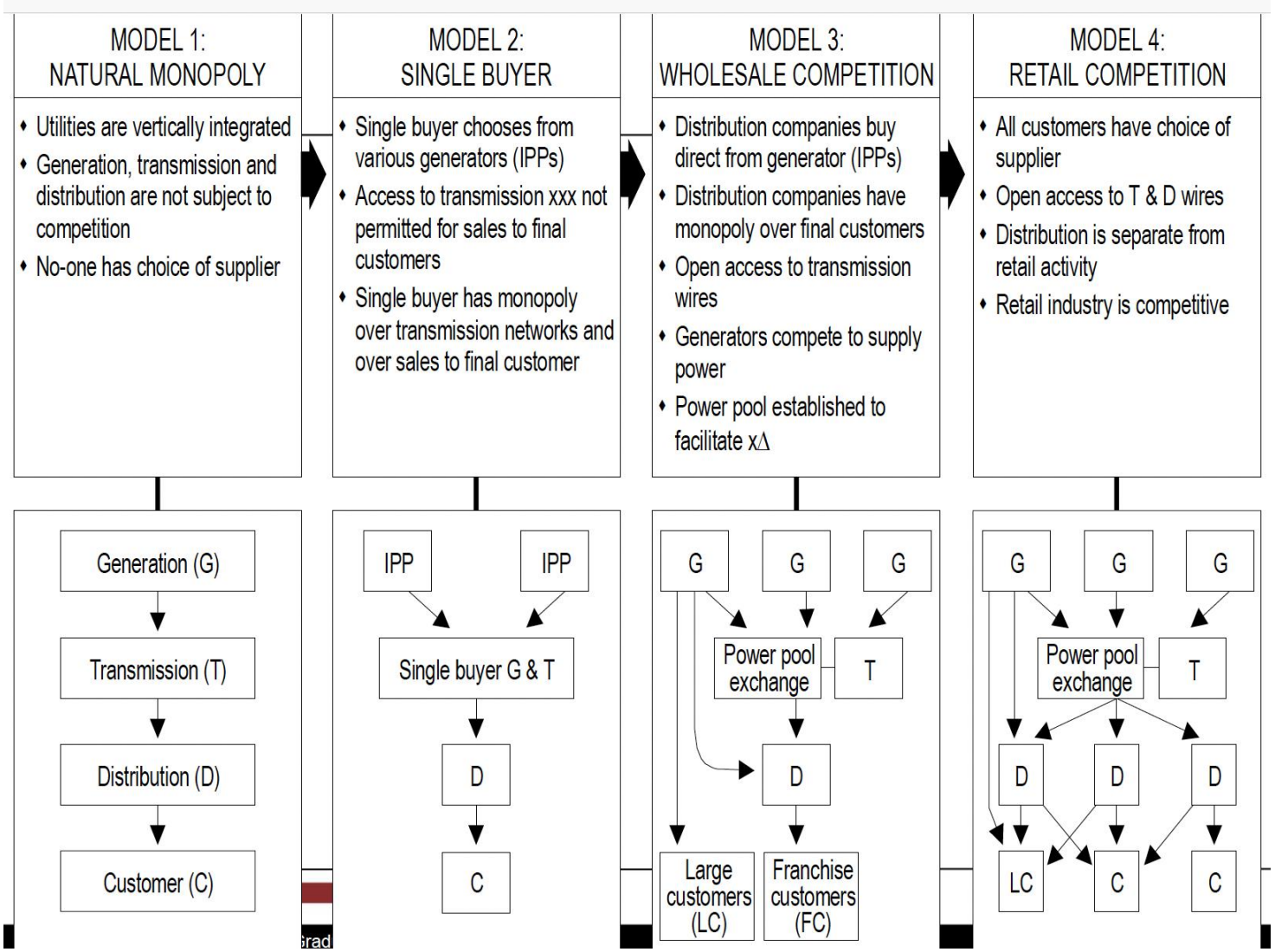
Power market governance framework



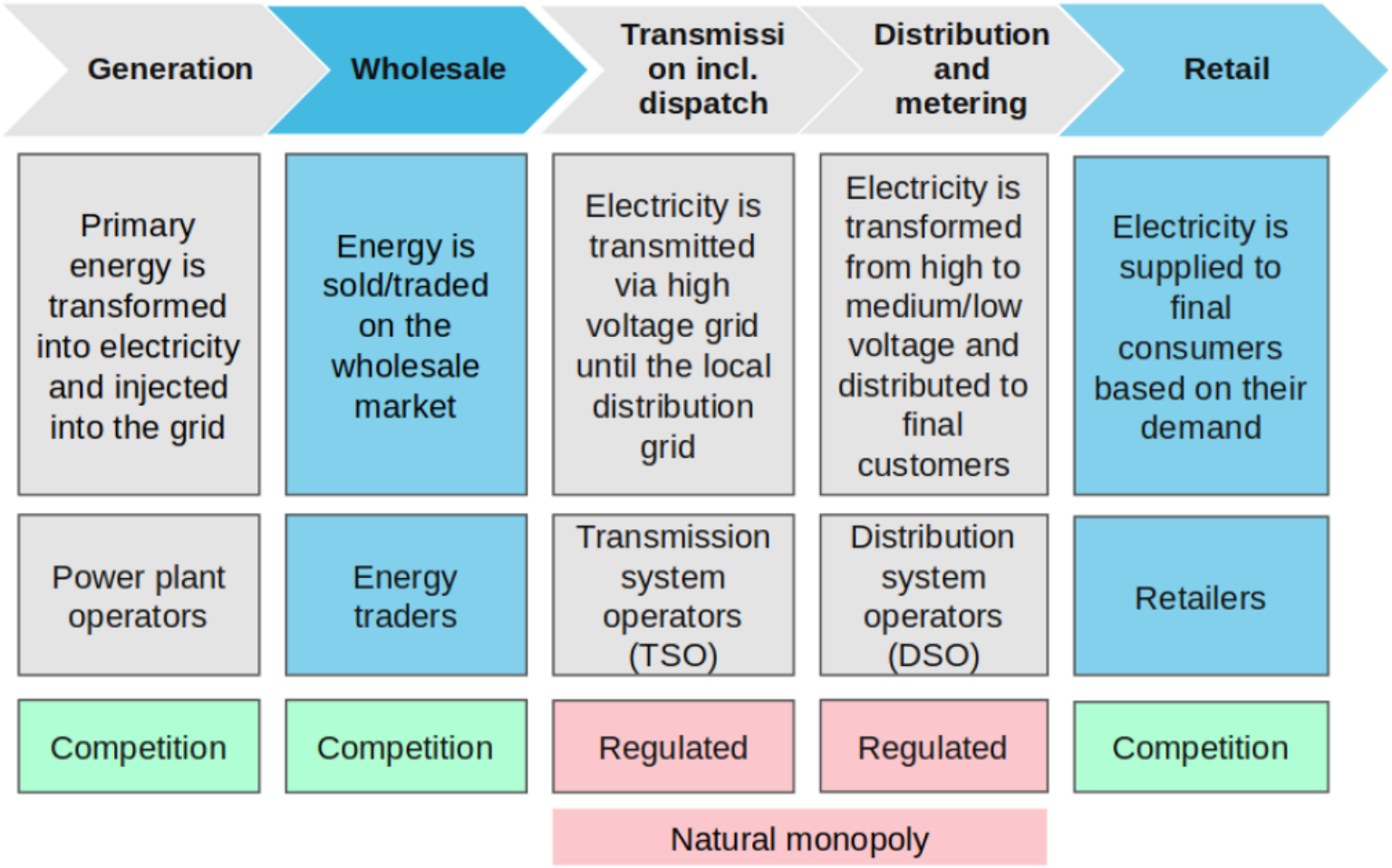
Source: Adapted from Delloite Touche Tohmatsu 2004; World Bank 2003c.

Source: WB, 2006

Power market structures

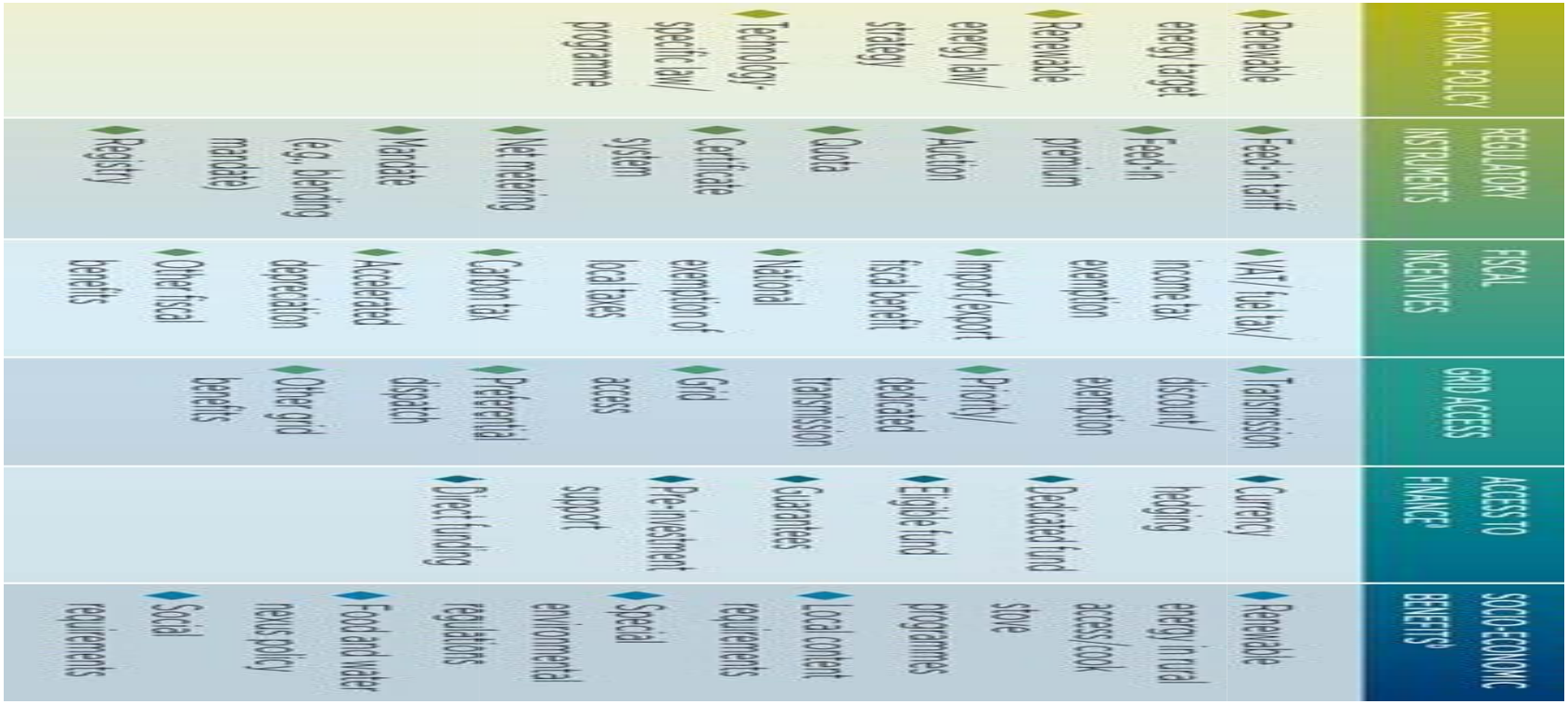


Electricity markets: main actors



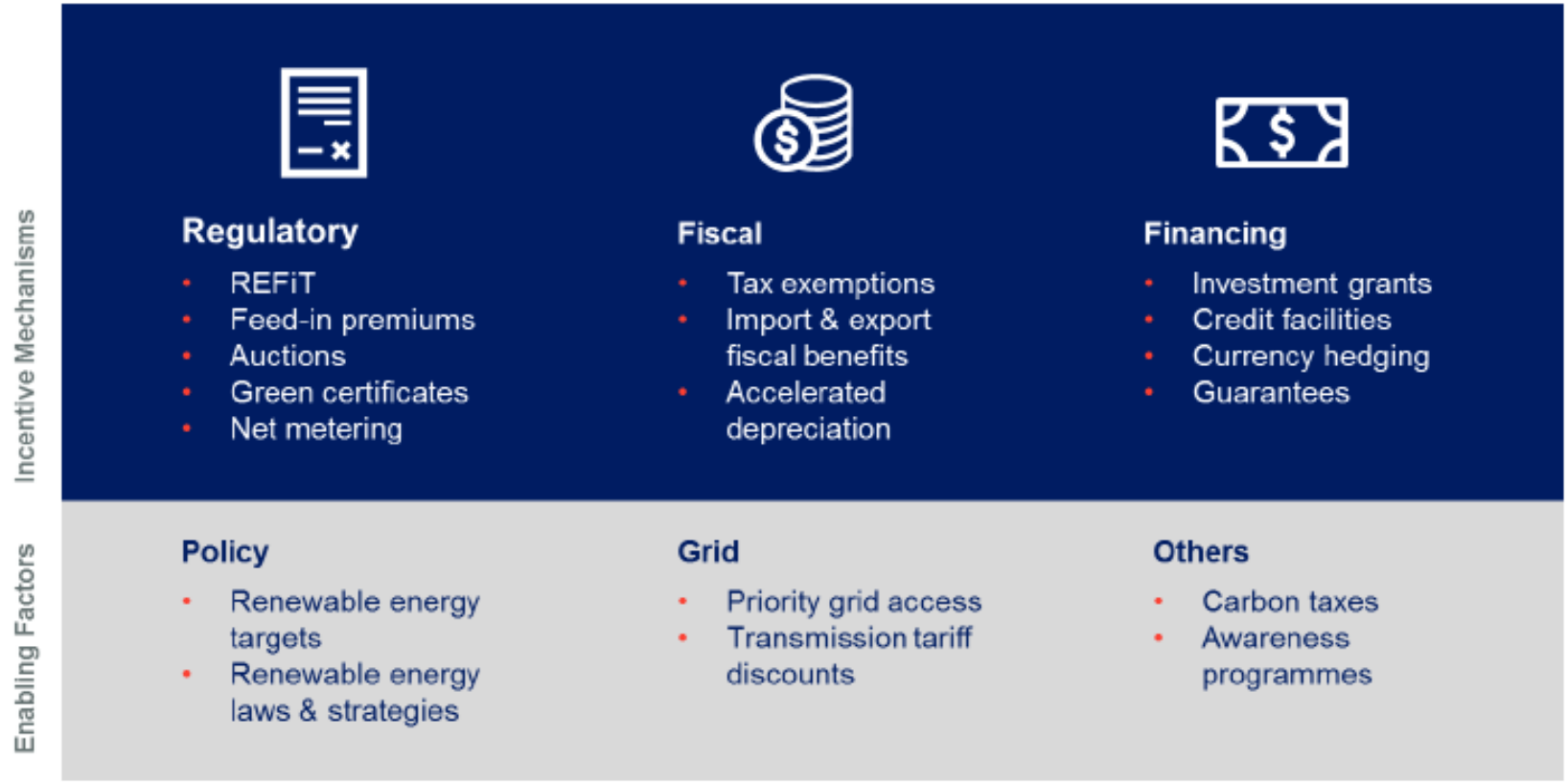
Source: TU Berlin

Types of renewable energy policies and measures



Source: IRENA, 2017

Common incentive mechanisms for promotion of renewable energy



Source: Adapted from IRENA (2015)

Source: ESREM

Description of incentive mechansisms for the promotion of renegry

Incentive Mechanism	Description
Regulatory incentive mechanisms	
REFiT and Feed-in premiums	A renewable energy feed-in tariff (REFiT) or premium offers cost-based compensation to renewable energy producers on top of the market price for electricity, typically per kWh produced. This provides price certainty and long-term contracts that may make financing more readily available. The main challenge is getting the tariff or premium level just right, and adjusting it as needed.
Auctions	An auction is a competitive process for procuring renewable energy generation capacity. In an auction, project developers bid against each other to supply energy through long-term contracts. Awards are generally made according to transparent criteria, including price. Auctions are often supported by other instruments, such as guarantees and other fiscal benefits.
Renewable Energy Certificates (or Green Certificates)	Renewable Energy Certificates are a market-based instrument that certifies that a MWh of renewable electricity has been generated. Certificate schemes typically include a quota requirement governing how many certificates end-consumers have to buy based on their consumption. The certificates are issued to generators, who in turn can sell them to end-consumers (typically represented by utilities), creating a new revenue stream to help fund new renewable generation capacity.
Net metering (or net billing)	Net metering (or net energy metering) is an electricity billing mechanism that allows consumers who generate some or all of their own electricity to use that electricity anytime, instead of when it is generated. In a net metering scheme, the compensation is given in energy (i.e. in kWh), and the credit can be applied to offset consumption of electricity within the current billing cycle and even in future billing cycles. In net billing, the compensation is monetary.
Fiscal incentive mechanisms	
Tax exemption	Tax incentives for renewable energy projects are typically offered in the form of reductions in sales, energy, value-added or other taxes. They may also be offered as tax credits.
Import & export fiscal benefits	Fiscal import and export benefits can be offered in the form of reduced charges and duties on i) imports of goods and services required for construction of renewable energy power plants and accompanying infrastructure, or ii) export of renewable energy.
Accelerated depreciation	Accelerated depreciation allows greater depreciation in the early years, reducing the tax burden of renewable energy assets.
Financing incentive mechanisms	
Investment grants	Investment grants are offered by governments or other entities (e.g. development partners) to partly or fully finance studies or private capital investments to increase renewable energy generation capacity.
Credit facility	A credit line is a loan that is disbursed by a funder to one or more intermediary financial institutions for them to on-lend to end-borrowers, aiming to address one or more credit market failures and increase lending to renewable energy projects. A credit facility will always consist of one or more credit lines but can also include supportive design elements such as guarantees and technical assistance.
Currency hedging	Currency hedging is a strategy designed to mitigate the impact of currency or foreign exchange risk on international investments returns, such as lending in local currency.
Guarantees	A guarantee is a financial instrument that is similar to an insurance policy. For a fee, it provides financial compensation for the financier if the borrower is not able to pay back.

Source: ESREM

Thank You