Balancing Incumbent and Opposite Perspectives on Key Issues in the 100% Renewable Electricity Transition

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ABSTRACT

Several renewable electricity supplies disrupt incumbent power generation and distribution systems, because of their variable nature and lack in flexible dispatching by central authorities. The latter is due to technical factors and to non-technical attributes like ownership, demand conditions, and regulatory conventions. As spontaneous default position is accepted that the disruptor (renewable energy producers) should pay for the impacts they occasion on established systems and for the necessary expenses of adapting the systems for the growing shares of renewable electricity in total supplies. This paper challenges that dominant view by reverting the point of reference in asking respect for the "polluter pays principle": because the incumbent power systems are not sustainable they must adapt to the requirements of the renewable ones, not the other way round. The incumbent default and alternative perspectives are investigated and compared for a number of important issues, for example: asymmetries in supply liability, remuneration of surplus power supplies to the grid, pricing of back-up power from the grid to independent generators. The issues are often not well understood and generally contentious, but of high importance for the effective, efficient and fair transition from non-sustainable to 100% renewable power systems.

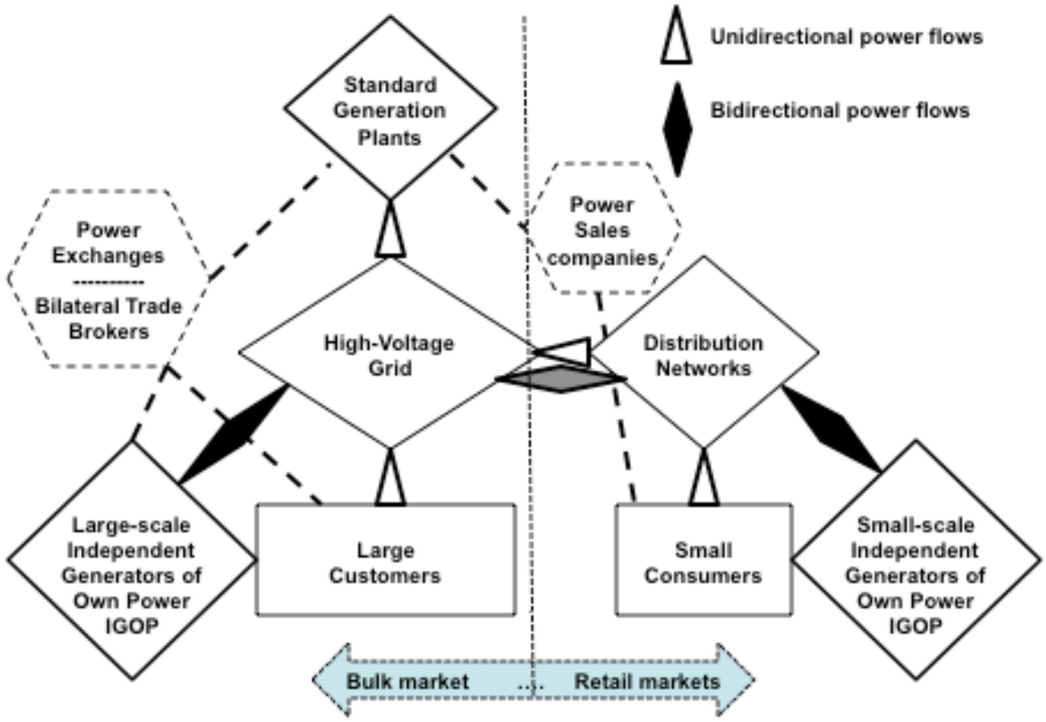
Keywords: renewable electricity integration, independent generators of own power,

This short paper first describes the main components and relationships in today's liberalized electric power systems (section 1). Section 2 identifies two classes of power suppliers: differently from the common central-distributed dipole, the classification consists of standard generation plants and of independent generators of own power (IGOP). Both the latter classes include renewable electricity (RE) providers. For being successful the 100% transition to RE will built on the unfettered growth of IGOP. However IGOP will poorly develop when a short-run market scope is imposed (section 3). Section 4 concludes with arguments for a comprehensive helicopter perspective on the issue of substituting RE, in particular renewable IGOP, for existing power systems. The polluter pays principle supports payment of the transition costs by non-sustainable incumbent producers.

1. Liberalized electric power supply systems

Liberalization of electric power systems started during the 1980s (Joskow and Schmalensee 1983) and ever since affected national power systems on a global scale. In February 1997 the EU published a directive on the internal energy market (electricity and gas), but its design and implementation delivered a variety of mixed market structures all over Europe (Glachant and Finon, 2003). Figure 1 shows the main components of present-day electric power supply systems in Europe, and their relationships. The left side of figure 1 represents the bulk electricity market; the right side the retail markets within a given geographical area.

Figure 1: Components and relationships in liberalized electric power supply systems



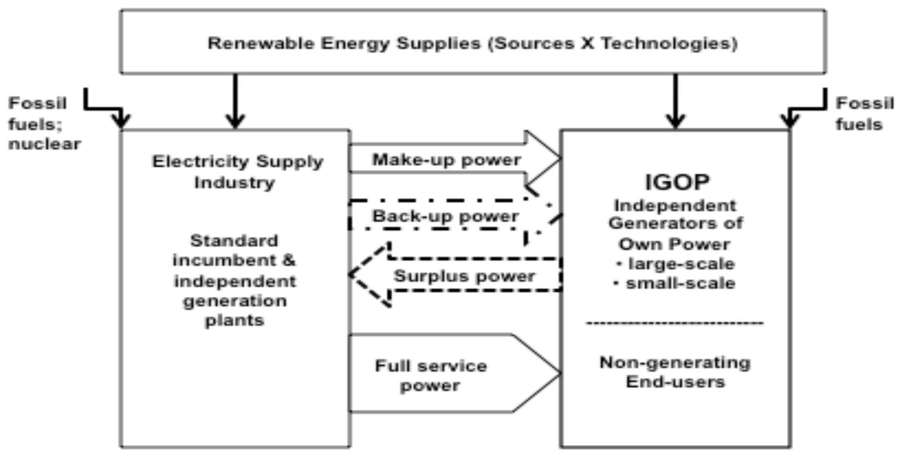
Before liberalization, electricity supply was a fully vertical integrated industrial activity covering generation, transmission, and distribution. Investment and operational decisions were optimized with the help of scientifically based methodologies. Central supervision provided stability and neat balancing of supply of and demand for the non-storable power flows. Continuous equilibrium was maintained by internal system operators, entitled with full command (dispatching) over the own generation capacities, and with back-up by colleagues in adjacent control areas (IPCC 2011). Electricity sector liberalization intended to substitute free market principles for vertically integrated supply structures. However, realizing workable competition in such tightly managed systems was contingent on a logical sequence of prerequisites, viz. proper harmonization of rules and conditions for participants in the "competitive" markets, transparency of the institutions and activities, unbundling of the main functions (generation, transmission, distribution), and firm guidance and supervision by excelling independent regulators (Verbruggen 1997).

Figure 1 shows a structure with unbundling of power generation activities, the high-voltage grid transmitting bulk power to demand nodes, and distribution companies operating low-voltage networks to serve the electricity retail demands. Liberalization forced unbundling in the processing of physical power flows, and added several new entities, such as power exchanges, bilateral trade brokers, power sales companies (also called suppliers), embroiled as intermediaries in contracting power transactions. The new institutions function on legal and financial terms, apart from the physical electricity flows. Figure 1 omits to highlight important participants in today's power supply systems like system operators and regulatory institutions.

2. Two main classes of power generators

Most literature classifies power generators in central and distributed, with definitions however unsettled, leading to diverging interpretations and quantifications of their roles and shares. A stricter identification of generators in two main classes depends on univocal attributes, as follows: "Standard Generation Plants" are permitting full dispatching of their capacity on command (top of figure 1). It encompasses the production facilities of previously vertically integrated *incumbent* power companies, mostly consisting of (also very large scale) capacities. This class also includes *independent* power producers that primarily generate power to sell to customers through the power system. Liberalization has blurred the differences between incumbent and independent standard generation. Both may deploy conventional nuclear or fossil fuel technologies, combined heat and power, or renewable supplies (biomass, hydro, wind, etc.). The independent plants mostly will be more distributed than the larger-scale plants of incumbent companies. The other class of power generators (bottom of figure 1) are – large and small – "Independent[1] Generators of Own Power (IGOP)": they run power plants to serve primarily the own loads but in interaction with the – high-voltage and low-voltage – power grids. They are often named "on site" generation because they are placed at the premises of large customers (industrial plants, commercial sites) or of households and small businesses. IGOP use fossil fuels (often cogeneration or combined heat and power units) or renewable sources and technologies.

Figure 2: Two main classes of power generation



[1] The adjective independent is added to distinguish from joint-ventures between incumbent companies (owning several standard power plants) and industries that house the (combined heat and) power plant.

Standard (incumbent or independent; central or distributed) generation plants are single-directionally linked to the power system: they only deliver power. IGOP (large-scale and small-scale) are bi-directionally linked (figures 1 and 2). IGOP mostly switch roles from (net) producer to (net) consumer of electricity, forth and back. When technically feasible and financially opportune IGOP first serve the own loads and eventually send surplus power to the grid. When the own load exceeds the power output of the IGOP plant, electricity is imported from the grid as "make-up" or as "back-up". The distinction between the latter flows is important when electricity tariffs include a high fixed term (price per monthly kW-peak) argued as coverage of high costs of investment in base-load plants. In the transition to 100% renewable based power systems, the role of IGOP will grow in importance to become the most common and predominant type of power supplies.

3. Integrating IGOP in power systems

Most literature on the integration of renewable electricity in power systems focuses on the North-West part of figure 1 (e.g., IEA 2011). Some sources also highlight the role of distribution networks (e. g., de Jode et al. 2009). The technical aspects of system stability (frequency), of balancing of demand and supply (load following), and of adequacy (sufficient capacity to reliably meet (peak) loads in the future) receive most attention (IEA 2011; George and Banerjee 2011). The financial trade-offs behind the investments and operations are not commonly documented. Costs also can be shifted around (IEA 2011) what makes accurate assessments precarious.

Table 1: Market price of a kWh supplied depends on five variables, implemented differently by IGOP and by Standard generation plants

Market price of a kWh supplied depends on	*Independent generator of own power (IGOP)*	*Standard generation plant*
Time of delivery (synchronous with system base to peak load fluctuations)	Delivery not at command, but net power offered according source supplies (renewable) and own demand for power or for heat (cogeneration)	Delivery at command when unit committed in advance; variable RE contribute when sources deliver on time of request
Speed of delivery (immediate, within seconds, minutes, hours)	Most IGOP capacity not available for dispatching.	Plants ready for dispatching but limited by ramping rates and flexibility; some plants specialized in flexibility
Place of delivery	Distributed locations near load centers, creating meshed deliveries	Central large-scale stations supply bulk of generation; renewable sources often distant from the grid
Reliability	Source, technology, project, environment, … specific	Source, technology, project, environment, … specific
Liability	Deliver power in surplus of own needs; IGOP switch roles producer-consumer	Produce power on demand – shunt power if not demanded

Table 1 provides an overview of five variables affecting the transient quality and therefore the market price of the supplied kWh. In text is assessed how IGOP and how standard power generators perform on the five variables. From table 1 it follows that electricity forthcoming from IGOP scores a lower market price than electricity from standard generation plants, the latter being exclusively dedicated to serve the market. Leftover to the established systems and institutions, it is unlikely that IGOP may win the uphill market battle against incumbent power generators.

4. Conclusion: Opposite perspectives on integrating renewable supplies

When accepting that RE, in particular RE built and operated by IGOP, have to become the default generation option in a 100% RE system, a comprehensive helicopter view on the integration issues is requested. If direct competition in the short-term between established power systems and IGOP challengers is the norm, the latter will fail to develop (table 1). There are two arguments for overcoming the fallacy of direct competition, and for molding the 100% RE systems of the future as the reference to construct. The minor argument is that today's power supply systems are distant from market competitive optima as hailed in the economics literature. The major argument is that today's power supply systems are completely grown adverse because of unpaid externalities and unpaid risks of its major energy conversion plants based on fossil fuels and atomic power. The "polluter pays" principle legitimates the imposition of obligations on incumbent power companies to pay for the costs of transitioning from existing high-carbon and high-risks systems, inherited from the fossil and nuclear era, to future low-carbon RE systems (Verbruggen and Lauber 2012). This implies for instance that the costs of integrating RE supplies in existing central power systems and the expenditures for adapting the systems fall largely or entirely on incumbent interests. This approach opposes claims for charging costs of disturbing incumbent production and transmission systems on RE supplies when the latter make inroads on existing power systems.

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