Powergrids: Enabler or Bottleneck of the Energy Transition: The future of the Distribution System Operator (DSO)

Michael G. Pollitt

Judge Business School

University of Cambridge

ENBW-CEEPR-EPRG

Berlin

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Plan

- Some facts about DSOs
- Activities of the DSO
- Optimal scale and scope
- Regulation of the DSO
- Concluding thoughts

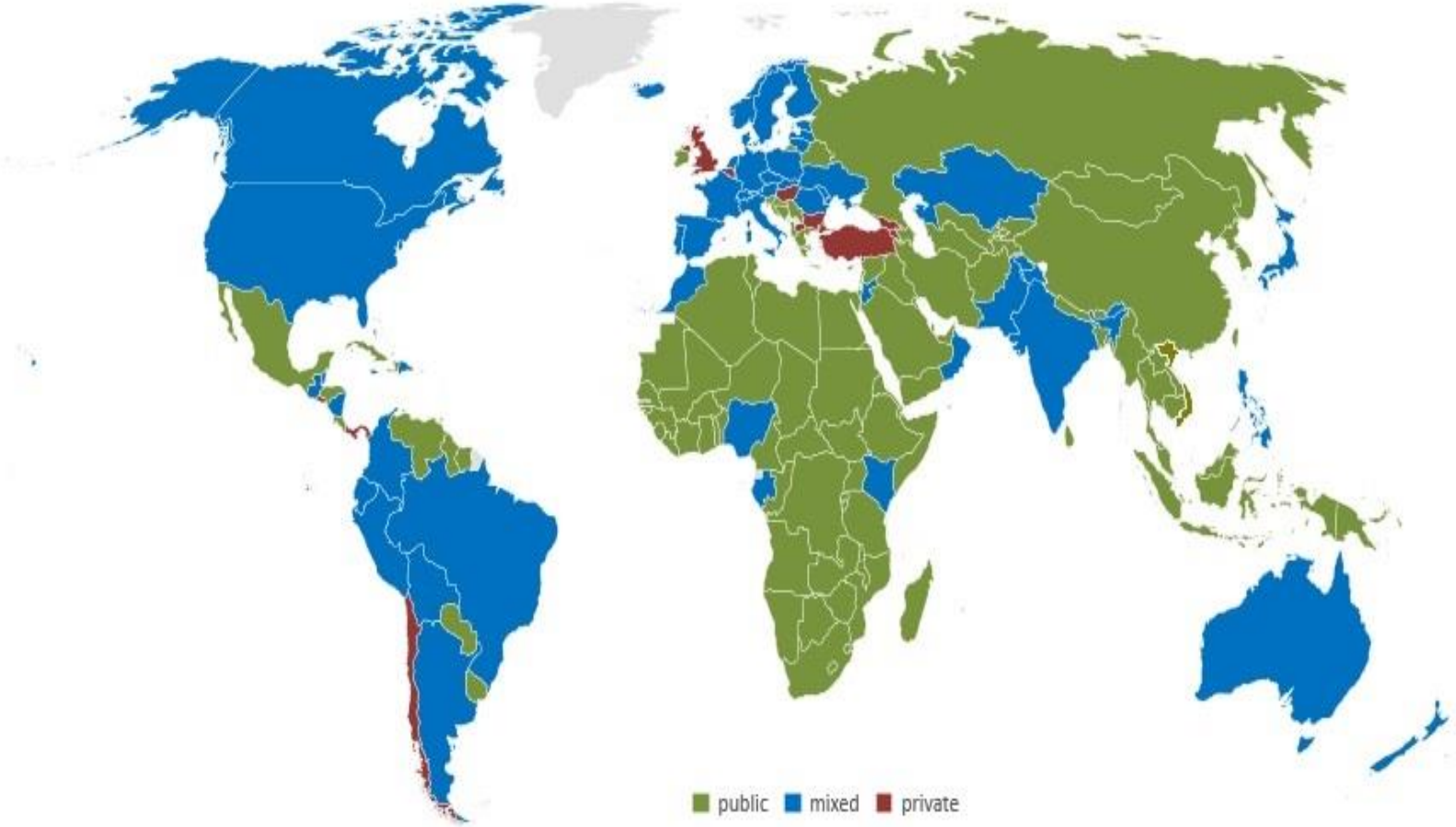
- *With thanks to Sinan Kufeoglu and Karim Anaya*

Some facts about DSOs

- There are roughly 7600 across 175 countries.
- Distribution (D) legal structure is often combined with retail (R); transmission (T); and generation (G).
- Roughly 2900 are legally separated from G,T and R. Most of the rest combine with at least R.

The public sector is dominant in DSOs

Figure 5, Ownership of the DSOs



Source: Kufeoglu, Pollitt, Anaya (2018)

Largest publicly owned DSOs

Table 5

Largest 5 publicly owned DSOs in the world

DSO	ownership	number of customers (million)
State Grid Corporation of China	public	447
China Southern Power Grid[1]	public	122
Perusahaan Listrik Negara, Indonesia	public	64.3
Federal Electricity Commission, Mexico	public	34.9
TEPCO[2], Japan	public	29.5

[1]Estimated in ratio to State Grid Corporation of China

[2]State controls equivalent to 90%+ of stock.

Source: Kufeoglu, Pollitt, Anaya (2018)

Largest mixed/private DSOs

Table 6

Largest 5 mixed and private owned DSOs in the world

(Mixed assumed to be more than 10% public and private)

DSO	ownership	number of customers (million)
ENEL, worldwide	mixed	65.5
Enedis, France	mixed	36
Endesa, Spain	private	22
E.ON, Europe	private	17
RWE, Europe	private	16.5

Source: Kufeoglu, Pollitt, Anaya (2018)

The legal structure of DSOs

Table 4

Summary of the legal structures of countries

legal structure	no. of countries
D	42
T, D	9
T, D, R	4
G, D, R	12
G, T, D, R	97
other	11

In most countries DSOs are legally integrated with other parts of the sector…

Source: Kufeoglu, Pollitt, Anaya (2018)

Countries with largest DSOs (by population)

Country	No of DSOs	Legal Structure	Ownership	Access to electricity (%)	Population (thousand)	Population without electricity connection (thousand)	Connected Population per DSO (thousand)
China	2	T, D, R	public	100	1,378,665.00	0	689,332.50
Indonesia	1	G, D, R	public	91.2	261,115.46	22,978.16	238,137.30
Mexico	1	G, T, D, R	public	99.2	127,540.42	1,020.32	126,520.10
Vietnam	1	G, T, D, R	public	98.3	92,701.10	1,575.92	91,125.18
South Korea	1	T, D, R	public	100	51,245.71	0	51,245.71
South Africa	1	G, T, D, R	public	86	55,908.86	7,827.24	48,081.62
Ethiopia	1	G, T, D, R	public	40.4	102,403.20	61,032.31	41,370.89
Algeria	1	G, T, D, R	public	100	40,606.05	0	40,606.05
Thailand	2	G, T, D, R	public	100	68,863.51	0	34,431.76
Saudi Arabia	1	G, T, D, R	public	100	32,275.69	0	32,275.69

Source: Kufeoglu, Pollitt, Anaya (2018)

Countries with smallest DSOs (by population)

Country	No of DSOs	Legal Structure	Ownership	Access to electricity (%)	Population (thousand)	Population without electricity connection (thousand)	Connected Population per DSO (thousand)
Finland	80	D	mixed	100	5,495.10	0	68.69
Austria	138	D	mixed	100	8,747.36	0	63.39
Sweden	170	D	mixed	100	9,903.12	0	58.25
Iceland	6	D	mixed	100	334.25	0	55.71
Kiribati	1	G, T, D, R	public	48.1	114.39	59.37	55.02
Czech Republic	290	D	mixed	100	10,561.63	0	36.42
Norway	146	D	mixed	100	5,232.93	0	35.84
Estonia	37	G, T, D, R	mixed	100	1,316.48	0	35.58
Maldives	35	G, D, R	public	100	417.49	0	11.93
Switzerland	900	G, D, R	mixed	100	8,372.10	0	9.3

Source: Kufeoglu, Pollitt, Anaya (2018)

DSO/TSO boundaries

- Countries with highest highest distribution voltages (e.g. Russia 110kV)
  - UK – 132kV
  - US - 33kV
  - Germany - 110kV

- Countries with the lowest lowest transmission voltages (e.g. Chile 23kV)
  - UK – 275kV/132kV
  - US – 69kV
  - Germany - 220kV

What does the electricity system do?

- 4 crucial functions of electricity industry (MIT Utility of the Future Report, 2016):

- Market platform
- Network provider
- System operation
- Data management

- Electricity network as a platform market (see Weiller and Pollitt, 2016)

What do DSOs do?

- Network provider - yes
- System operation – a bit
- Data management - sometimes
- Market platform – not yet..

- TSO does all of these, but will/can a DSO?

The future of the DSO: Activities

Allowed and prohibited activities and grey areas for DSOs
CEER (2016)

Allowed activities	Prohibited activities	Grey areas
• Planning, developing, operating and maintaining the network • Connecting users to grid • Load shedding • Managing technical data • Managing network losses	• Energy generation • Energy supply	• Managing metering data for small end customers • Monitoring grid and voltage related constraints as more RES connects to DS • Infrastructure for EVs • Ownership/management of meters • Flexibility services – but don't inhibit market for aggregators

More grey activity implies the need for more separation.

Data Management and the DSO

- Retail Data Hubs are considered for providing secure and equal access to data and increasing efficient communication among network operators, suppliers and prosumers.

- DSOs provide them in Belgium, there is a Central Market System (CMS) operated by ATRIAS (ATRIAS, 2018).
- In Norway, ElHub is designed to enable efficient use of smart metering through more efficient communication and data management and it is operated by the Norwegian TSO Statnett (NVE, 2017).
- In the UK, a Data Communications Company (DCC), Smart DCC collects and provides smart meter data to all players in the energy system and is wholly owned by an outsourcing company, Capita plc.

DSO as a platform market

- The issues for the DSO are:
  - Decline in supply from large power plants
  - New distributed energy resources (DER) available
  - Increased requirements for ancillary services
  - Quality issues with DERs vs large scale providers
  - Complexity of optimally dispatching small DERs
  - Managing TSO-DSO relations in service provision
    - ‘boots on ground’ vs ‘techie skills’
    - Co-ordination vs competition
    - Nature of economies of scale and scope
  - Same problem in many jurisdictions (e.g. SEM. CPUC, NYISO)

How will DSOs be structured in the future?

- Starting points matter: both role of T and capacity of D.
- Still many DSOs integrated fully with other parts of the system and/or too small or a too low a voltage to do much by way of platform market functions.

- Ownership structure depends on costs and the benefits.

Vertical separation of the DSO

- Pros of separation:
  - Lack of distraction on generation
  - Focus on network performance KPIs
  - Promotion of innovation, DERs etc.
- Cons of separation:
  - Lack of access to skills and coordination
  - Lack of capital strength
  - Vertical integration (VI) only option for islands
  - Storage classified as G, so cannot own it.

Some structure questions

- Which functions will be undertaken by the DSO?
  - Network service
  - System operator
  - Platform markets
  - Data management
- If current/future DSO functions are not undertaken by DSO, who will undertake them?
  - TSO-TO-SO
  - DERs / Generators / Aggregators
  - Customers / retailers

Economies of scale and scope

See Pollitt and Steer (2012)

- Economies of Scale (if greater than 1) for producing vector of outputs q:

$$Sca = \frac{C(q)}{\sum_{i=1}^{n} q_i C_i(q)}$$

  - Where C_i is the marginal cost of producing output i.
  - This says adding up outputs from different stages reduces costs.
- Economies of Scope (if greater than 0):

$$Sco = \frac{C(q_1, 0) + C(0, q_2) - C(q_1, q_2)}{C(q_1, q_2)}$$

  - This says joint production reduces costs relative to separate production.

Difficulties with concepts

- EoScope implies EoScale and hence higher vertical scope may be motivated by lack of horizontal scale.
- Measurement of different outputs difficult.
- EoScope can be exploited by non-integrated firms – e.g. Orchard/Sheep in Teece (1980).
- Defining a transaction cost boundary between firms (f. Williamson, 1975) can be expensive in governance cost but this cost is likely reducing.
- Asset specificity is endogenous.
- Access regulation can encourage separation.

Benefits of Competition *(Hay and Liu (1997)*

- In general (across industries) benefits are:
  - Information discovery and selection important
  - A sharpening of managerial incentives

- Less competition reduces larger firms incentives to cut costs.
- Loss of market share stimulates firms to improve their efficiency.
- R&D important for long run efficiency.

Observations

- Competition allows scale and scope economies to be exploited without integration.
- Different degrees of asset specificity can make the degree of integration endogenous.
- Technology and history are significant in determining optimal scale and scope at any time.

The interests of future regulation

- If the future will be characterised by more distributed generation (DG) and demand side management (DSM) (=DERs).
  - This must mean active DSO networks.
  - Increasing potential conflict between distribution, retail and DERs.
- Economic Regulation will continue to focus on:
  - Monopoly power of DSOs with respect to both
  - Development of competition for DSO services
  - Quality of service effects of DG/DSM
  - Data protection/privacy issues
  - Financial regulation of entities selling to consumers
  - Implications for particular consumer groups
  - Fair return to network investors

The future structure of the electricity system

- Total TSO vs Total DSO at heart of electricity system? (see Kristov et al., 2016) Currently battle for control of future by TSO and DSO in the UK.
- *A total DSO must be separate from retail* (and generation and transmission).
- Microgrids, consumer capital and decline and centralised power system?
- But what about need for centralised power grid and seasonal/transnational transfers of power?
- Retail contracts continue to be under regulatory pressure and this limits scope for competition and long term investment.

Concluding thoughts

- Scale and scope of actual DSOs vary enormously and general lack of reform of DSOs.
- No clear right answer to future structure at the moment, especially as scale and scope difficult to link to actual legal structure….
- Logic of more clarity of roles and increased separation of remaining monopoly from the rest seems likely…
- Regulators will rightly want to limit activities of DSO to encourage innovation and protect past investments.
- Can be enablers if promote low cost, secure, lower carbon system, but not guaranteed to do this…

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