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

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# *Plan*

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

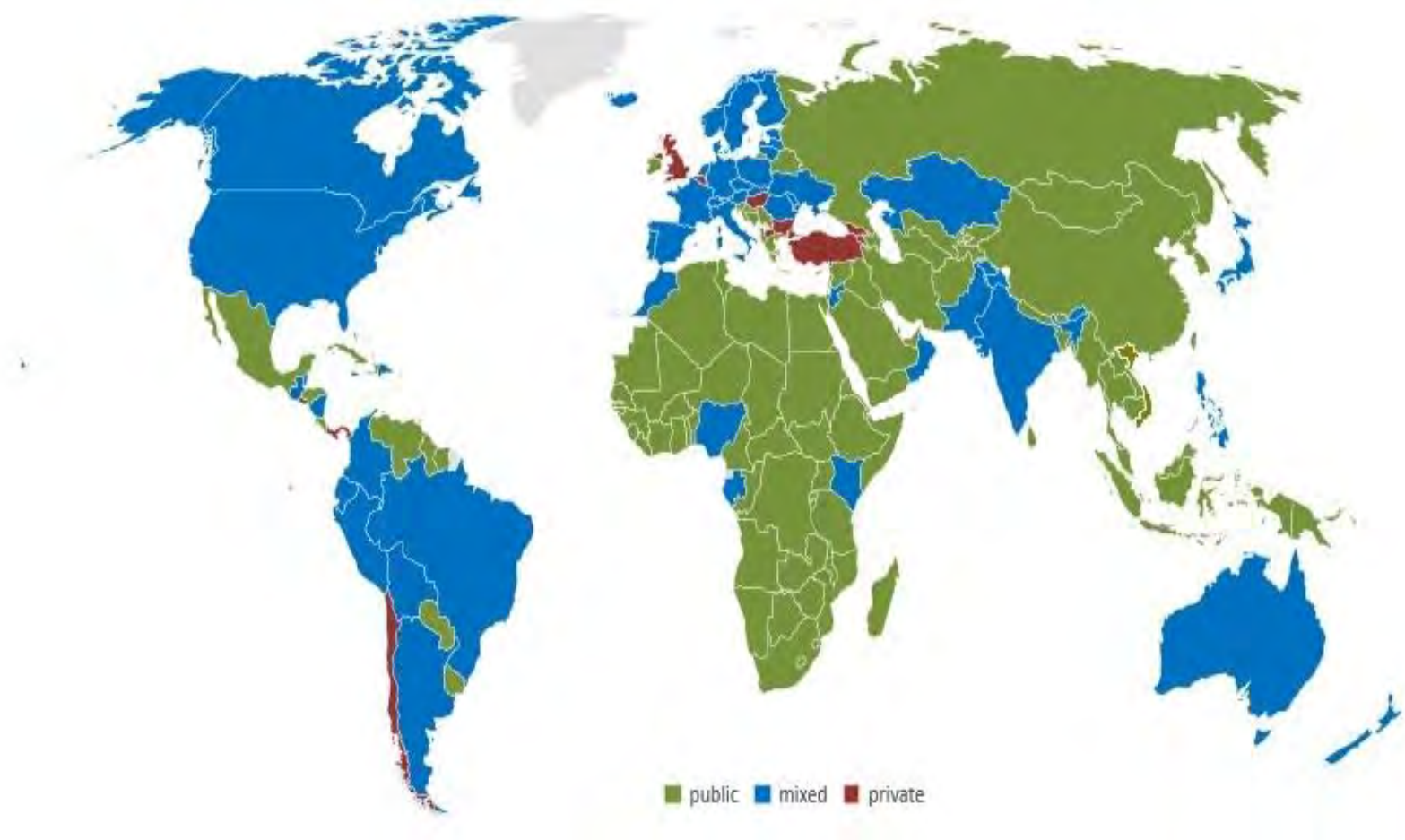
- *With thanks to Sinan Kufeoglu and Karim Anaya*

# 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<br>• Connecting users to grid<br>• Load shedding<br>• Managing technical data<br>• Managing network losses | • Energy generation<br>• Energy supply | • Managing metering data for small end customers<br>• Monitoring grid and voltage related constraints as more RES connects to DS<br>• Infrastructure for EVs<br>• Ownership/management of meters<br>• 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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