The Lebanese Electricity Sector: A Polycentric Viewpoint

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ABSTRACT

This paper presents a new theoretical approach to design a polycentric electricity sector. The study focuses on Lebanon and its electricity sector, and tries to reform the sector using a proposed polycentric structure.

The study utilises the polycentric indicators and general structure, along with organisational modes, and electricity market design variables to come up with a standardised stepwise model, i.e. "Polycentric Market Design Framework", to design a polycentric hybrid electricity sector. This is followed by applying it to the Lebanese case.

Two important outcomes are gained from this study, (i) that the polycentric indicators developed for the energy infrastructure are better suited to develop a polycentric design for the electricity sector when compared to the more comprehensive design used in the LSP framework; (ii) the Polycentric Market Design Framework (PMDF) could be generalisable for other cases when designing a polycentric electricity sector.

1. Introduction

The Lebanese electricity sector suffers from immense reliability problems that causes power outages to be a daily routine to the Lebanese consumer. Power rationing is used by the state-owned monopoly, i.e. Electricite du Liban (EdL), to distribute the limited amount of energy capacity to consumers, and power outages varies between 3 to 12 hours a day depending on the region of the country (Verdeil, 2016). Lebanese consumers rely on independent energy providers (IEPs), i.e. small diesel generators, to mitigate these daily outages (Ghanem, 2018). In the meantime, several energy reform policies have failed to be implemented and transform the sector into a well-functioning one, and this is mainly attributed to the political-sectarian system of the country (Ibrahim et al., 2013).

Numerous studies were conducted to address the current situation of the Lebanese electricity sector and the barriers that hinder its development (Ghanem, 2018; Verdeil, 2016; Ibrahim et. al, 2013; Khodr and Hasbani, 2013; Fardoun et. al, 2012; Ruble and Nader, 2011). However, no found studies analyses or prescribe a reform solution to the sector. Therefore, thesis attempts to reform the Lebanese electricity sector, and uses a novel approach in an attempt to surpass the political system in the country as well as taking into account the societal and economic need in Lebanon.

An interesting and unconventional description of the electricity infrastructure comes from Künneke and Finger (2009) and Goldthau (2014), where the authors identify the infrastructure as a common pool problem. In-line with this definition, Goldthau (2014) calls for a polycentric governance for the sector, in which it can provide solutions at multiple levels (centralised and decentralised), and therefore allowing for higher integration of decentralised generation options. An identification of polycentric energy infrastructres was carried out by Sovacool (2011), where the author explored several [polycentric cases and was able to argue that polycentricity is able to promote "equity, inclusivity, information (distribution of data), accountability, organisational multiplicity, and adaptability".

Given the above reasons, the thesis believes that polycentric governance can be a solution to a hybrid (centralised and decentralised generation) electricity sector in Lebanon. The article proceeds in section 2 by describing the theoretical framework used to design a polycentric hybrid electricity sector. Section 3, presents the Lebanese case, where it explains the situation of the electricity sector and the socio-political and economic context of the country. Section 4, designs the polycentric hybrid sector for Lebanon where it follows the design steps assigned in section 2. The fifth section, discusses the prospects for implementing the new-found design. The sixth and final section, reflects on the findings and concludes with a set of recommendations.

2. Research Framework

According to literature (Goldthau, 2014; Scholten, 2013; Loorbach et al., 2010; and Smith et al., 2005), the electricity infrastructure fits the definition of a socio-technical system. This definition emphasizes two things for this study, (i) that the electricity infrastructure is actually embedded in its surrounding, i.e. its society, (ii) when addressing the complex issue of the electricity sector, e.g. designing of a new structure for the Lebanese electricity sector, both technical and institutional/market aspects of the sector must be considered. however, given the way polycentricity is defined the thesis chooses to focus on the market design side of the electricity sector. Nonetheless, the technical side will not be totally neglected, therefore at the end of the market design exercise the study will allocate the responsibilities of safeguarding the technical functions of the electricity system to the appropriate actors, along with the institutional arrangement to execute the function.

For the rest of this section, the objective is to explain the theoretical framework for designing the polycentric

sector. The chapter has four sections, with the first section introducing the concept of polycentricity and relates it to the electricity sector. The second section explains the modes of organisation which are utilised to explains the relations between the different layer within a polycentric structure. The third section, explains the different market design variables and their respective options which are utilised as the tactics to operationalise the strategy of the structure, i.e. taken form polycentricity. The final subsection, describes the "Polycentric Market Design Framework" (PMDF), which is a stepwise mechanism to design a polycentric hybrid electricity sector.

2.1. Polycentricity

2.1.1.Concept and Indicators of Polycentricity

The foremost concept that this thesis is building on is polycentricity, which was first envisaged by Michael Polanyi and later introduced to governance studies by Vincent and Elinor Ostrom (Aligica and Tarko, 2012). V. Ostrom, Tiebout, and Warren (1961, p. 831), characterise polycentric structure by multiple levels and/or centres of governing authorities rather than a centralised one.

An important aspect of this concept is that larger units, e.g. centralised regulator, may intervene to resolve problems associated with "local tyrants, non-contributors, or inappropriate discrimination", and can even incentivise new innovations (Ostrom, 2010). The figure below (fig. 1) shows a general structure of polycentricity for governing decentralised resources.

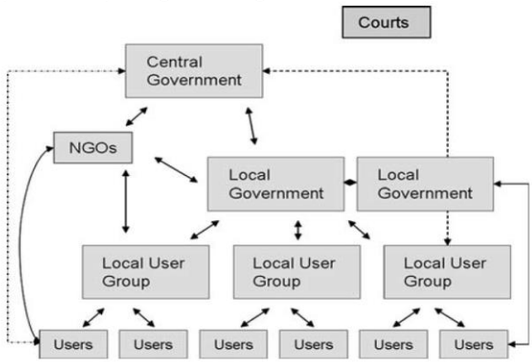

Figure 1: The conceptual model of decentralized resource governance from a polycentric perspective. Source: Andersson and Ostrom (2008, p. 78).

Aligica and Tarko (2012) developed a robust analytical structure called "Logical Structure of Polycentricity" framework, which is utilised for the study of complex phenomena, e.g. socio-technical systems. This study treats the indicators found in this framework as constraints that govern the strategy for designing the sector, the main indicators are:

a. *Active exercise of diverse opinions* (P1)
b. *Autonomous decision making* (P2)
c. *Incentive compatibility, alignment between rules and incentives* (P3)

The rest are visible in the LSP framework (figure. 2).

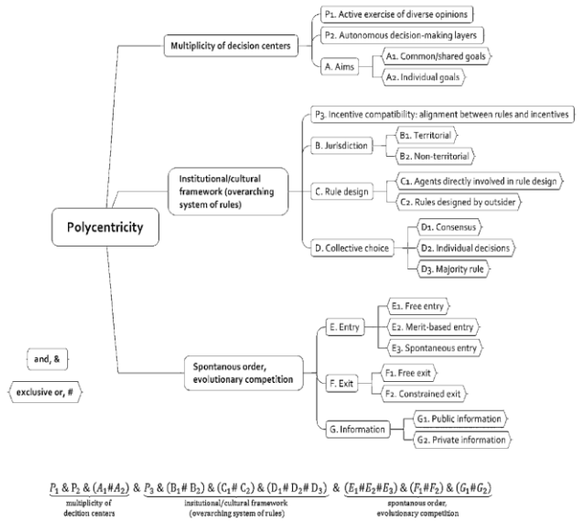

Figure 2: Logical Structure of Polycentricity. Source: Aligica and Tarko (2012, p. 257).

2.1.2.Polycentricity in the electricity sector

Polycentricity in the energy infrastructure was studied by Sovacool (2011), where he was able to identify a set of variables (indicators) that gave an inclination towards a more effective polycentric energy governance, those variables are:

a. Equity
b. Inclusivity
c. Information monitoring
d. Accountability
e. Organisational multiplicity
f. Adaptability

No contradiction is found between the set of indicators; however, the LSP framework give a more comprehensive view for the designer. Therefore, the LSP indicators are applied at the beginning as the constraints for designing the polycentric sector. A later conclusion will be made regarding the suitability of which of the two sets of variables.

Forming the structure of the polycentric electricity sector was a result of combining the structure given by Andersson and Ostrom (figure. 1), the above identified polycentric indicators, and the actors found in an electricity sector that follows the retail-competition market model. The reason behind choosing the electricity actors based on the retail-competition model is the inclusivity and the widest possible number of actors in this model.

Figure. 3 shows the resulting structure, where the central government in figure. 6 is represented here by the centralised generation, TSO, and electricity regulator. Assigning the electricity regulator's position can change depending on the final design; this is the case if the designer chooses to opt for a regulator at the regional/local level instead of a national regulator. However, given the nature of the regulator's job in a liberalised electricity sector, one can deduce that along with the courts the electricity regulator plays the role of resolving/preventing possible conflicts that might arise between the different actors in the sector.

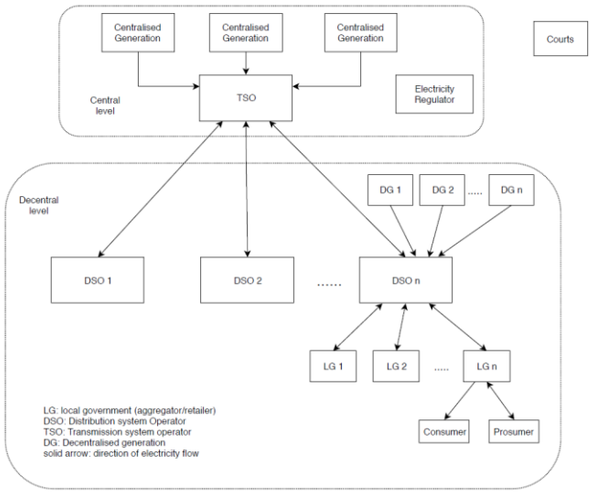

Figure 3: Polycentric structure of a hybrid electricity sector

2.2. Modes of Organisation

Modes of organisation is an integral factor in this thesis, where they are seen as the tool to govern the relation between the different actors in the polycentric structure of an electricity sector. Organisational structures vary from centralised forms to completely decentral operations (Scholten, 2013). In order to capture the various modes/structures of governance, this thesis opted to investigate the works of Ménard and Shirley (2008), Provan and Kenis (2008), and Scholten (2013); four modes of governance could be distinguished from the above studies:

a. Vertical integration
b. Lead Organisation
c. Participant-governed (common operation)
d. Incidental Coordination

Both "Lead organisation" and "Participant" modes come closest to the concept of hybrid arrangements as defined by Ménard (2008). The concept of hybrid arrangements is defined as a set of autonomous organisations/entities that participate in a set of arranged agreements to do business together to achieve a certain end goal.

The definition of hybrid arrangements, and the three fixed indicators of polycentricity (P1, P2, &P3) match together; in which it is clear to see that both the chosen governance modes call for the exercise of autonomous decision-making organisations. Hybrid arrangements, i.e. lead and participant modes, call for active exercise of opinion through their modes of collaboration and interaction that happens amongst the network members.

Therefore, this study accepts that both modes of organisation or a combination of both can represent relations between layers/actors in a polycentric structure.

2.3. Market Design Variables

The objective of this section is to present the market design variables along with the respective design options that are utilised as the tactical options to achieve the final design of the polycentric hybrid electricity sector (figure. 8). The following design thirteen variables, are taken from the study of Littlechild (2003), whereas the design options per step are taken from studies by de Vries (2007), Correljé and de Vries (2008), Bauknecht and Brunekreeft (2008), de Vries et al. (2010), and Bell and Gill (2018).

Determining the degree of market opening, which discusses the degree of competition and openness of the market. Options are:

a. Corporatisation of the state-owned monopoly.
b. Single buyer model
c. Wholesale market model
d. Retail market model

Second variable is the "pace of market opening", i.e. either a follower or a leader.

Third variable is network unbundling, i.e. distribution and transmission networks. According to de Vries et al. (2010), network unbundling influences the incentives and independence of network managers to provide equal environments for network users. Options for unbundling are accounting, legal, or ownership unbundling (de Vries, 2007).

Fourth variable is "integrated vs. decentralised market". Two options exist for this step, either integrated or decentralised markets. An integrated market signifies that congestion management is integrated in the market clearing.

The fifth variable is deciding upon the "balancing mechanism" strategy. However, if the market is integrated (step 4), then a balancing mechanism is not needed (de Vries et al., 2010).

The sixth variable is "Congestion management method". The design options for this step are:

a. Nodal pricing (integrated market)
b. Counter trading
c. Re-dispatching
d. Explicit auctions
e. Market splitting

Seventh variable is congestion management at the interconnection, i.e. with neighbouring countries.

Eighth step is the ownership issue. Four options for ownership can be found in the literature, private, public, public private partnership (PPT), or commons ownership. When it comes to ownership four important decisions would have to be taken:

a. Ownership of DSO.
b. Ownership of TSO.
c. Ownership of centralised generation.
d. Ownership of decentralised electricity production.

Ninth variable is "Network regulation of network tariffs and access conditions". This is linked to the incentives given to either TSO and DSOs. An inappropriate distribution of risk between actors will act as hinderance to achieving the objective of low-cost electricity system (Bell and Gill, 2018), as well as culminating to a chaotic polycentric sector (Aligica and Tarko, 2012). The main concern in this study is the incentives and network regulation for the DSO.

Tenth variable is "Wholesale and end-user price regulations". This is aimed at protecting consumers from volatile and high prices; however, there exists a trade-off between the interest of consumers and investment incentives for generators to cover demand.

Eleventh variable is "capacity mechanism" issue. However, if retail competition does not exist, then this step is not required (de Vries, 2007). When retail-competition exists, one of the following options could be used:

a. Capacity payments
b. Strategic reserve
c. Operating reserves pricing
d. Capacity requirements
e. Reliability contracts

f. Bilateral reliability contracts; or
g. Capacity subscriptions

Twelfth variable is the "position of regulator". According to de Vries et al. (2010), the regulator's position could be at the local, provincial, national or supranational level. For a polycentric structure, the position would either be at the national (Central) or Decentral level. However, it was recommended above for a polycentric structure to have the regulator at the central level.

The thirteenth and final variable is "competition policy and horizontal unbundling". This variable serves the purpose to decide on the kind of competition law utilised to regulate the sector. Two options reside for this step, either a sector regulation law that targets the sector alone, or to make the competition in the sector follow the general competition law of the country.

2.4. The Polycentric Market Design Framework

This section presents the necessary steps for designing a polycentric hybrid electricity sector. Those below steps form the structure for this thesis to design the Lebanese polycentric electricity sector, and were determined from the above discussed sections:

1. Start with the general structure of a polycentric electricity sector (figure. 3), polycentric indicators, and the actors found in the retail-competition model of an electricity sector.
2. Investigate and decide on the relevant actors with respect to the case in hand, e.g. Lebanon in this study. This step ultimately decides the shape of the sector, and answers the first market design variable, i.e. the "degree of market opening".
3. Select the geographical jurisdiction of each of the centres, i.e. the DSO's and its accompanying actors (DGs and LGs). This matches the indicator B1 in the LSP framework.
4. Investigate and decide on the mode of organisation that will govern the relation between the different levels in the polycentric structure. The choice is limited to either the "lead organisation model" or the "participant-governed".
5. Make a choice on which of the remaining market design variables are relevant to your case.
6. Select the market option per market variable. Each selection is constrained by the context of your case, and the previous choices made in the above steps.
7. Create a conceptual framework that describes the pathway towards achieving the new electricity sector design.

3. Case Study and Methodology

This section investigates the peculiarities of Lebanese electricity sector along with that of the country's context (socio-political and economic). The section starts by introducing the methodology used to investigate the Lebanese case, and to get answers when designing the polycentric sector (section 4).

The strategy in selecting the interviewees for this thesis was based on the knowledge and perceived added value of the interviewees towards the findings of this thesis. The author decided to interview experts that are mainly knowledgeable in the fields of electricity market design, and the Lebanese electricity sector. Information from experts who have knowledge in market design was used to design the proposed polycentric electricity sector, while experts in the Lebanese sector were interviewed to validate the design, check its feasibility, and acquire some information on the Lebanese electricity sector. The list of interviewees is shown below, where category one reflects interviewees utilized for designing the sector, and interviewees belonging to category 2 were utilized to for validating the design and providing other important information.

Interviewee number	Expert Name	Category	Institution	Position	Relevant Expertise
1	Bhagwat, Pradyumna Dr. M.Sc.	1	Florence School of Regulation	Research Fellow	Energy policy and regulation
2	Bhagwat, Swetha M.Sc.	1	Florence School of Regulation	Research Associate	Technology, policy & regulation, finance and business development in the renewable energy sector.
3	De Vries, Laurens Dr. ir.	1	Delft University of Technology	Associate Professor	Electricity market design
4	Ghajar, Raymond Prof. dr.	1 & 2	Lebanese American University. Ministry of Energy & Water	Dean, School of Engineering. Senior Energy Advisor at MoEW	Electricity utility restructuring (Lebanese situation)
5	Hammoud, Sami M.L.	2	Private office	Lawyer	Lebanese constitution and judiciary system
6	Ibrahim, Oussam Dr. M.Sc.	2	Lebanese University	Lecturer	Research in the Lebanese electricity sector
7	Ismail, Ali M.Sc.	1 & 2	Electricite du Liban (EdL)	Head of Dispatch Centre	Technical knowledge of the Lebanese sector
8	Jamasb, Tooraj Prof. dr.	1	Durham University – United Kingdom	Chair in Energy Economics, and Co-Director at the Durham Energy Institute	Energy sector reform and market liberalisation (developing countries)
9	Khazzaka, Raymond	2	Private sector	Independent Energy Provider	The sector of Diesel Generators in Lebanon
10	Mortada, Sorina Dr. M.Sc.	2	Lebanese Centre for Energy Conservation. Lebanese University	- Technical Consultant. - Associate Professor	Renewable energy in Lebanon
11	Mubarak, Sameh	1 & 2	World Bank	Senior Energy Specialist. Energy Extractives Global Practice, MENA region.	Electricity sector reform in Lebanon
12	Yorke-Smith, Neil Dr.	1	Delft University of Technology	Associate Professor	Socio-Technical Algorithmics and knowledge in the Lebanese case

Table 1: List of interviewed experts

3.1. Lebanon's Electricity Sector

Two important headlines from the current situation of the sector could affect the design of the polycentric electricity sector. The first relates to the general aspects of the sector, while the other relates to the aspects of the non-implemented 2010 energy policy that can still assist in developing a new polycentric design for the sector. Aspects of the first headlines relate to:

- Lebanon's electricity sector is owned by a vertically integrated state monopoly called Electricite du Liban (EdL).
- On average, 60% of the consumer's electricity comes from EdL, while the rest comes from other sources, and mainly from IEPs (Ghanem, 2018). IEPs rely on small diesel generators, that are decentralised, and each IEP has his/her own private network.
- Distribution services are outsourced (concessions) to three private companies, i.e. management unbundling from the rest of the electricity value chain.
- High technical losses at the transmission and distribution networks. Transmission network capacities are low (grid and substations).
- High electrification rate, i.e. almost 100%. This is good news for a developing country, and thus would not pose problems for design.
- High theft percentage, i.e. estimated at 20%, at the distribution network.

As for the recommendations given by the 2010 policy paper, the following points could be used to assist in designing the polycentric electricity sector:

- The current situation at the distribution network, i.e. DSPs, and the already divided

service areas. This is used as the geographical jurisdiction for the centres at the "decentral level" in the polycentric structure.

- Incentivise public private partnership (PPP) at both the generation and distribution levels. Example, IPP at the centralised generation level, and private management at the distribution level.
- Transmission: this value was kept within the jurisdiction of EdL, and investments needed for expansion and improvements would be financed through the government and international loans.
- Tariffs: increasing the tariffs gradually in connection with reliability improvements and abolishing subsidies, except for low income consumers and productive sectors.

3.2. Lebanon's Socio-political and Economic Context

The following lists the contextual aspects that must be kept in mind while designing the sector:

- Sectarianism: the political context of the country, where confessionalism leads to the division of power between the various sects. This obstacle is considered to be the most complicated aspect that is slowing down decision-making (Khodr and Hasbani, 2013).
- Politicised decision-making: the LNG terminal is a prime example
- The high-level of debt/GDP ratio, and the high percentage of poverty
- Absence of policy continuity: where the 2006, 2008, and 2010 policies have stalled for long time. However, this is starting to change, and some hope resides with points connected to the 2010 policy.
- Continuous conflict with Israel and terrorism crossing from the Syrian borders (after the conflict started in 2011).

The question would be, would the concept of polycentricity be able to circumvent the above obstacles or at least part of those obstacles. The thesis argues that using polycentricity in the electricity sector to combine centralised and decentralised generation is a solution to avoid the conflicts inflicted by sectarianism and politicised decision-making. The thesis believes that such a design would actually please the different political parties in Lebanon. This is further solidified through the intention to divide the country into different distribution zones based.

4. A Polycentric Design for Lebanon

Figure. 4 below shows how would the polycentric hybrid electricity sector for Lebanon looks. Two stakeholders are located at the central level in Lebanese design, which are EdL and the electricity regulator. EdL is responsible for transmission duties as well as centralised generation. Centralised generation can either come from the existing generation capacity that is owned by EdL, or from IPPs that will serve the purpose of replacing existing plants when decommissioned. At the decentral level, three DSOs representing three different regions in Lebanon and each one is regarded as the main player in that respective region. The jurisdiction of each DSO is based on the current division, which ensures socio-political approval, technical applicability, and optimum economic benefit (number of consumers, area covered…. etc.), and besides this jurisdiction is already in place which ensures the acceptability by the decision-makers in the government. Legal unbundling is preferred between distribution and transmission for Lebanon, with the need to hand operation and management to private companies through concessions for further developing the network. The DSOs in figure. 4 are labelled with the current private companies that manage and operate each jurisdiction, however this is a mere representation and does not have to hold. Electricity only flows one way from the central level towards the decentral level, where there is not current technical possibility of having a two-way flow of electricity. At each DSO level medium-sized decentralised generation are connected to the distribution network, and this is done through shallow connection charges and locational based incentive mechanism for the DNuS. The DGs are selected based on the CDS auctioning mechanism. Each DSO acts as the retailer in its respective region, and no possibility of retail competition would exist in Lebanon. Therefore, consumers are directly linked to the DSO for sale, but they have the possibility to turn into prosumers by producing electricity through solar power and sending it back to the grid (two-way flow of power). Balancing at the distribution side is handed over to the DSOs, and the balancing mechanism to handle the relation between the DSO and TSO is done through the devolution principle.

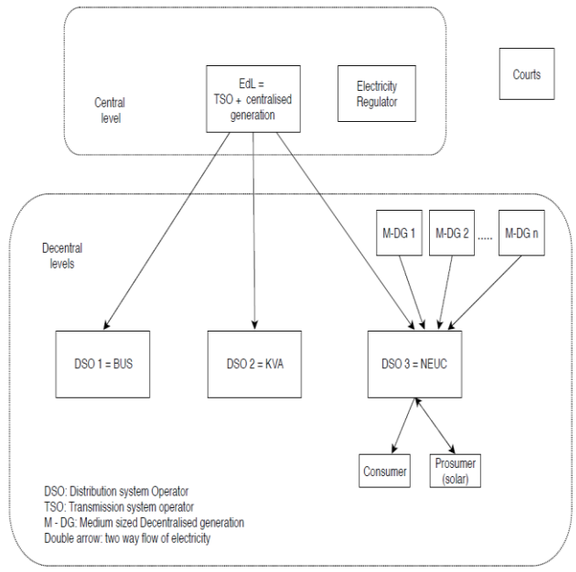

Figure 4: The polycentric structure for the hybrid electricity sector in Lebanon

5. Acceptability of the Design

This section discusses the acceptability of the general polycentric structure for the case of Lebanon and argues that existing technical and institutional conditions in the electricity sector are suitable to move into the recommended design.

The term "acceptable" is of significance to this study, in which it is attributed to being acceptable by both the political regime and the public's eye. For the political regime, the design should be able to bypass the previous bottlenecks that lead to other policies not being implemented, i.e. confessionalism and sectarianism. As for the public's opinion, the design should end the unreliability of the electricity sector whilst providing consumers with lower end prices compared to the current situation.

To start with, the general structure of the design, i.e. figure 14, was introduced to several of the Lebanese interviewees. Interviewees 4, 6, 7, and 10 expressed

their approval and saw the added value of the design; the interviewees saw the design as a way to circumvent either the political or the technical barriers facing the electricity sector. According to interviewee 4, introducing decentralised generation would mitigate the political contest between parties on the location of the large centralised generation plants. Interviewee 7 stated that the strategy this thesis took to design the sector is very much logical with the Lebanese political context, and is in-line with the current situation of dividing the distribution network into three zones operated by Distribution Service Providers (DSP). The design also mitigates the technical barriers that are present at the transmission network (capacity of lines and capacity of substations). Interviewee 11 expressed a positive viewpoint regarding unbundling distribution from transmission, and saw that the current trend for the electricity sector is going in that direction. The interviewee along with interviewees 4 and 7 believed that the situation of the DSPs is here to stay and might develop further.

Two other important aspects that the design is able to mitigate are security concerns and quick implementation time (interviewee 4 and 7). For the first concern, introducing decentralised generation and handing over operating and management powers to the DSO could simplify the matter, thus identifying geographical locations where non-technical losses are happening and coming up with a solution for that area that is able to alleviate security concerns. As for the issue of fast implementation, this advantage comes from the current fiscal situation of the Lebanese government and the high losses incurred by the government from the electricity sector.

6. Conclusion

This study started with the objective to design a polycentric hybrid electricity sector for the Lebanese case. The intention of the design was to help Lebanon overcome its barrier (political and social) and to achieve a reliable electricity sector, and to a large extent the thesis and the presented design were able to achieve the objectives. Whether to call the design a polycentric one might be up to different interpretations; if the second category LSP indicators are essential concepts and indicators for the realisation of a polycentric structure, then the proposed electricity sector design could not be fully described as a polycentric one. However, if interpreting polycentricity comes from the indicators (variables) that are described by Sovacool (2011), then the proposed design did adhere to those indicators and thus it can be categorised as a polycentric electricity sector.

This study was able to achieve several other important outcomes, most notably is the comparison between the comprehensive and general indicators of the polycentricity, i.e. found in the LSP framework, and the indicators given by Sovacool (2011) which describe a polycentric energy infrastructure. The study believes that Sovacvool's narrower indicators, that do not contradict the LSP's indicators, are better served to be utilised as constraints to design a polycentric hybrid electricity sector.

Another important outcome of this thesis is its ability to create a novel approach to design a polycentric hybrid electricity sector. The approach termed, the "Polycentric Market Design Framework" is believed to be generalisable and has the possibility of serving serve other cases to design a polycentric electricity structure.

The following recommendations also serve the purpose of progressing with this study to achieve the final aim of an acceptable and reliable polycentric electricity sector in Lebanon:

- Investigating ways to implement the seventh step of the PMDF.
- Exploring the compatibility of the DSO model presented in figure. 12 to the Lebanese context. This could have been established by investigating the distribution service providers (DSPs) in Lebanon, e.g. interviews.
- Investigating the possible effects of the proposed design on the Lebanese society and the possibilities that such a design is reinforcing sectarian conflicts instead of reinforcing social capital. If the former is found to be true, it is my belief that such a design should not be implemented in Lebanon, and an alternative electricity market design should be investigated.
- Investigating the congestions management method for the proposed Lebanese design.
- The optimum balancing cost distribution between DSO and consumers.
- Exploring the hedging mechanism which is supposed to protect the DSO from the uncertainty created in the Devolution principle for balancing costs. The hedging mechanism should remove any deterrent for the development of renewable energy sources.

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