Considerations for Economic Regulation Amendments to Incentivize Flexibility Utilization in the Finnish Transmission System

Antti Kuusela
Antero Reilander
Suvi Peltoketo
Antti-Juhani Nikkilä
Fingrid Oyj
Helsinki, Finland
antti.kuusela@fingrid.fi

Pertti Järventausta
Faculty of Information Technology and Communication Sciences
Tampere University
Tampere, Finland

***Abstract*—This paper provides considerations for economic regulation amendments to incentivize flexibility utilization in the Finnish transmission system. An investment deferral shall produce higher economic efficiency if the incurred costs of flexibility utilization are lower than the costs of a comparable investment during the evaluation period while the increase of service output remains the same. The analysis in this paper evaluates costs and benefits for a transmission system operator, connecting party and society in the regulatory regime applied in Finland. Incentives for flexibility utilization are missing from the current revenue capped rate of return regulation. The analysis results show that beneficiaries of flexibility utilization in the current regulation are the society and connecting party while TSO's efforts to defer an investment would have negative economic impact on its profit. Therefore, amendments to the economic regulation methodology are proposed to incentivize flexibility utilization when total welfare is increased.**

***Index Terms*--congestion management, economic regulation, flexibility incentive, investment deferral, on-demand flexibility**

I. Introduction

Renewable energy investments are progressing globally to meet the carbon neutrality goals set by multiple nations worldwide [1]-[2]. In addition to the political agenda, the penetration level of renewable energy sources (RES) shall increase rapidly since investments in RES have become commercially lucrative even without subsidies [3]. Transmission and distribution system operators (TSOs and DSOs) are facing a challenge to meet the demand for new grid connections, to provide needed transmission capacity, and subsequently to manage and operate a power system with a high share of weather dependent stochastic production while maintaining a high level of reliability [4]-[11]. New methods should be developed and employed to increase the utilization factor of the existing power system infrastructure. Utilization of on-demand flexibility in a transmission system has been proposed as a method of increasing grid hosting capacity and to provide a tool for operational planning [4], [12]-[14].

The vertical integration of electricity supply chain has been dismantled in EU member countries [15] and generally in the developed countries [16]. Electricity transmission and distribution companies are considered natural monopolies that are subject to economic regulation. In literature, two main schools of economic regulation are defined as a rate of return regulation and a price cap regulation [16]. In practice, the applied regulation policies in many countries include elements from both schools with added specific incentives [16]-[18]. The Finnish economic regulation methodology is a rate of return regulation with a revenue cap including incentives for investments, efficiency, quality, and innovations [17], [19]. However, there are currently no incentives for flexibility utilization. EU directs national regulatory authorities (NRAs) to set incentives for flexibility utilization [20]. The directive 2019/944 implementation into the Finnish legislation shall be completed in 2023 [21]. After the implementation, the NRA is obliged to amend the current regulation methodology. In this paper, the Finnish regulation methodology is presented and analyzed from the flexibility utilization point of view.

This paper provides considerations for economic regulation amendments to incentivize flexibility utilization in the Finnish transmission system. Utilization of on-demand flexibility is a technically feasible method of increasing grid hosting capacity and enabling an early non-firm grid connection of a wind power plant while deferring physical grid investments [4]. However, the method utilization increases operational costs in case of congestion. If all the incurred costs of on-demand flexibility utilization are lower than the costs of a comparable investment during the evaluation period while the increase of the service output remains the same, an investment deferral shall produce higher economic efficiency and is therefore justified. Thus, grid services would be supplied at lower unit cost and total welfare would increase.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739.

In this paper, the potential welfare generated by the flexibility utilization is examined through a demand-supply analysis. The basis for the study is the assumption that a TSO has two comparable options to increase grid hosting capacity and to provide demanded grid service output: to carry out needed physical grid investments, or to utilize on-demand flexibility in case of congestion. The welfare allocation between stakeholders may be asymmetric since the allocation of costs and benefits depends on contractual and regulatory constraints. To complement the demand-supply analysis, this paper provides a qualitative evaluation of welfare distribution between stakeholders. The analysis evaluates costs and benefits for a TSO, connecting party (CP), and society in the regulatory regime applied currently in Finland. The society includes all the grid service users in the power system. Based on the analysis, amendments to the prevailing economic regulation are proposed and the economic impact of the proposed amendments is evaluated.

The paper is organized as follows: Section II presents economic regulation and analysis of flexibility utilization, Section III presents proposed amendments to the regulation and analyzes its economic impact, Section IV discusses amendments and Section V compacts conclusions.

II. Economic Regulation and Flexibility Utilization

This section presents the rate of return regulation in general and the elements of Finnish regulation methodology more in detail. This section also provides a demand-supply analysis to examine welfare generation between conventional investment and flexibility utilization. To complement demand-supply analysis, a qualitative evaluation of welfare distribution between stakeholders in the current Finnish regulation regime is provided.

A. *Rate of return regulation and capital bias*

Revenue of a regulated company is determined in the rate of return regulation by the following (1):

$$R = s \cdot B + O + d + T \qquad (1)$$

Where R is revenue, s is rate of return, B is rate base, O is operational expenses, d is depreciation of assets and T is taxes. Profit of a regulated company is based on a rate, which is multiplied with a rate base. A regulated company shall make fair return in order to be able to acquire capital for investments to provide public services. If the rate of return is lower than the true opportunity cost of capital, the monopoly company cannot invest and the optimal solution for the company is to shut down operation [17]. It has been pointed out that the rate of return regulation inherently incentivizes companies to overcapitalize i.e., prefer investment in assets over operational expenses since profit is generated through investments [16], [22]. This is also called a capital bias. To avoid the capital bias, investments should be justified. Regulators tend to control the rate base for example by setting allowed unit prices for assets, defining a depreciation period per asset, and setting a rate of change limits to a regulated company's service pricing [16], [19].

B. *Regulation methodology in Finland*

The Finnish economic regulation methodology is a rate of return regulation with a revenue cap including incentives for investments, efficiency, quality, and innovations [17], [19]. The following (2) presents a simplification of the Finnish economic regulation methodology:

$$R = s \cdot B + O + d + I_{INV} + I_E + I_Q + I_{INN} \qquad (2)$$

Where the variables of (1) are complemented: I_{INV} is investment incentive, I_E is efficiency incentive, I_Q is quality incentive and I_{INN} is innovation incentive. An incentive for flexibility utilization is currently missing. It shall be noted that the incentives may increase or decrease the fair return of a regulated company.

In the Finnish economic regulation, the fair rate of return is determined by NRA based on the weighted average cost of capital (WACC) calculation. The rate of return is adjusted with the relevant corporate tax rate that explains why the taxes are excluded from (2) when compared to (1). The rate base comprises adjusted assets invested in electricity network operations. The NRA controls the rate base with given allowed unit prices and defined depreciation periods per asset [19]. Thus, revenue is capped with the rate of return and rate base regulation methods along with the introduced incentives.

Efficient investments are incentivized with an investment incentive (I_{INV}). If a regulated company manages to invest efficiently at a cost below the regulated asset unit price, it will receive a higher rate base than the actual investment. In addition, if an asset lifetime exceeds the depreciation period, a regulated company may continue to depreciate an adjusted straight-line depreciation of the asset as long as the asset is actually used. The purpose is to avoid early scrapping and incentivize asset utilization to the physical end of life. [19]

An efficiency incentive (I_E) encourages a regulated company to act cost-efficiently. Productivity shall increase over time and therefore the NRA requires an efficiency increase for controllable operational costs. Controllable operational costs such as personnel, external services, cost of leasing and other operating expenses, are the costs that a regulated company shall be able to control. The cost level per service output should decrease over time with a rate given by the NRA. [19]

A quality incentive (I_Q) aims to guide a regulated company develop grid service quality into a higher level than the minimum required by law. The incentive is evaluated by calculating a disadvantage of an outage per access point in the electricity system. The NRA sets a reference level based on to the performance level of the previous monitoring periods. [19]

The purpose of an innovation incentive (I_{INN}) is to encourage a regulated company for research and development to create innovative technical and operational solutions. The costs of research and development actions that produce new knowledge, technology, products, or methods for the industry shall be deemed acceptable. The results of matters subject to innovation incentive shall be publicly available. [19]

C. *Motivation for flexibility utilization*

To increase welfare, flexibility should be utilized whenever it is the most efficient techno-economical method of providing the required service output increase. This section provides a demand-supply analysis for two cases. The first case presents a conventional investment to meet the demanded increase in grid service output, the second one presents a case where flexibility is utilized to meet the demanded output increase. It is presumed that both cases are executed efficiently without unexpected anomalies that would bias the comparable analysis. The analysis assumes that all the incurred costs of flexibility utilization are lower than the costs of a comparable investment during the evaluation period while an increase of service output remains the same. The assumption may be considered fair since fault probability in a transmission system is very low [23], thus expected annualized operational redispatching costs in case of congestion are low as well [4]. From a regulation point of view the assumption shall be proven valid.

1) *Conventional investment*

The following demand-supply analysis in Fig. 1 presents a case where a physical investment in grid assets is utilized to increase the service output from Q_0 to Q_{i1} to match the increase in demand. The demand for the service output increases from D_0 to D_{i1}. The unit price for the service output remains the same in both cases (P_0 is equal to P_{i1}) since the fixed and marginal costs increase in proportion to the service output increase.

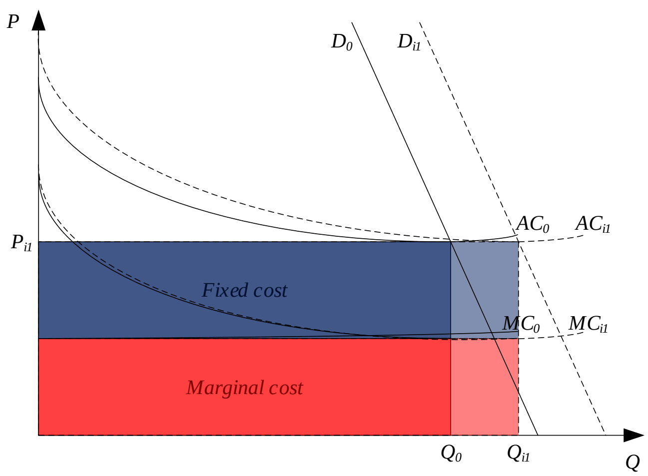

Figure 1. A physical investment in grid assets to increase grid service output. The demand for service output increases from D_0 to D_{i1}. Fixed and marginal costs increase in proportion to the service output increase from Q_0 to Q_{i1}. The unit price for service remains the same in both cases (P_0 is equal to P_{i1}). *AC* refers to an average cost curve and *MC* to a marginal cost curve.

2) *Flexibility utilization*

The following demand-supply analysis in Fig. 2 presents a case where flexibility is utilized to increase the service output from Q_0 to Q_{f1} to match the increase in demand. The demand for the service output increases from D_0 to D_{f1}. The unit price for the service decreases ($P_{f1} < P_0$) since the increase in marginal cost is smaller than the proportional decrease in fixed cost. The proportion of fixed cost decreases since physical investments do not increase. Marginal costs increase since operational costs increase due to flexibility utilization. Total welfare shall increase when an increase in marginal costs is smaller than the comparable avoided costs of a physical investment, i.e., $(Q_{i1} - Q_0)P_{i1} > (Q_{f1} - Q_0)P_{f1}$.

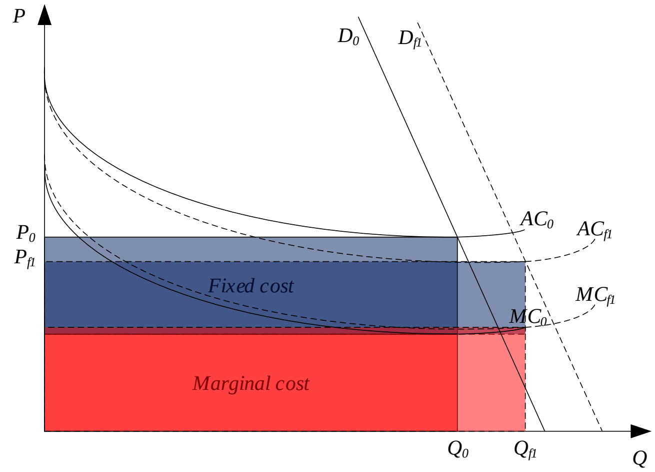

Figure 2. A flexibility utilization to increase grid service output. The demand for service output increases from D_0 to D_{f1}. Fixed cost decreases while marginal costs increase in proportion to the service output increase from Q_0 to Q_{f1}. The unit price for service decreases from P_0 to P_{f1}. *AC* refers to an average cost curve and *MC* to a marginal cost curve.

D. *Analysis of wellfare distribution in the current Finnish regulation regime*

This section provides a qualitative analysis of welfare distribution in the Finnish regulation regime in two cases that were presented in the previous section (II.*C*): conventional investment and flexibility utilization. Table I presents welfare distribution for a TSO, CP, and society in case of a conventional investment in a transmission system, where grid service output is increased through a physical investment in grid assets. Table II presents a comparable case where flexibility is utilized to increase grid service output respectively.

TABLE I. WELFARE DISTRIBUTION IN THE FINNISH REGULATION REGIME, CONVENTIONAL INVESTMENT

Welfare Distribution for Different Stakeholders	**Stakeholder**		
	TSO	***Connecting Party (CP)***	***Society***
Costs	Investment costs and operational costs increase in proportion to the service output.	Grid tariff fees.	Society (including CP) shall cover TSO costs through grid tariff fees.
Benefits	TSO profit increases since the rate base increases.	Grid service is available after TSO investment is complete.	Economic activity increases.
Summary	Business as usual.	Business as usual.	Business as usual.
Regulation methodology	Investment increases TSO assets, thus Rate base (*B*) and annual depreciation of assets (*d*) increases. Operational expenses *(O)* increase in proportion to the service output. No effect on the incentives.		

TABLE II. WELFARE DISTRIBUTION IN THE FINNISH REGULATION REGIME, FLEXIBILITY UTILIZATION

Welfare Distribution for Different Stakeholders	**Stakeholder**		
	TSO	***Connecting Party (CP)***	***Society***
Costs	Operational costs increase while rate base remains unchanged. Profit decreases.	Grid tariff fees. Possible operational costs. Part of flexibility operational costs may be allocated to CP.	Society (including CP) shall cover TSO costs through grid tariff fees.
Benefits	-	Early grid connection and rapid start of operational business. Lower grid service unit cost.	No increase in rate base, no depreciations. Lower grid service unit cost. Flexibility providers profit.
Summary	Rate base remains unchanged. Incurred operational costs decrease profit.	Operational business may begin swiftly. Possible operational and flexibility costs. Lower grid service unit cost.	Grid service is supplied at lower unit cost. Total welfare and economic activity increases. Flexibility providers profit.
Regulation methodology	Rate base (*B*) remains unchanged while operational expenses *(O)* increase. No depreciation (*d*) of new assets. Efficiency incentive (I_E) will have negative impact due to operational costs increase.		

Table I presented the status quo of today's business model where a TSO increases grid service output through physical investments into the grid assets. In addition, operational costs are inherently incurred in proportion to the service output. The current Finnish regulation aims to distribute the welfare fairly between stakeholders; TSO shall receive fair return to the invested capital, CP may start its operational business with fair grid tariff fees, and society benefits indirectly since new investments by the CP increases economic activity.

Table II presented a comparable case where a TSO utilizes flexibility to increase grid service output. Even though total welfare would be increased through flexibility utilization, current Finnish regulation would not share the benefit fairly between stakeholders. Due to the design of the regulation model, TSO's efforts to defer an investment would have negative impact on its profit since its operational costs increases while the rate base remains unchanged. Secondly, new staff, processes, and tools for managing the flexibility are needed, which increases operational expenses further. A CP and society are clear beneficiaries of the flexibility utilization. The CP would not have to wait for grid reinforcements and its operational business may start rapidly. However, the CP may have to bear some costs to enable technical capabilities for flexibility utilization, and possibly some operational costs of flexibility, depending on contractual terms with the TSO. Society (including CP) gains benefit through the higher utilization factor of prevailing grid assets which translates to a lower unit cost of grid services. In addition, a rapid increase in economic activity enhances welfare. Flexibility providers, as part of the society, profits due to an increase in operational flexibility procurement by the TSO.

III. PROPOSED AMENDMENTS TO THE REGULATION

The current regulation methodology in Finland does not incentivize flexibility utilization to defer an investment but quite the opposite, from a TSO point of view as presented in section II.*D*. The current regulation methodology should be amended to increase total welfare and to establish a fair distribution of welfare between stakeholders. The proposed amendments aim to complement the existing regulation methodology. The amendments consist of a proof of efficiency test, amendment to the existing efficiency incentive and new flexibility incentive.

A. Proof of efficiency test

In case of a TSO should increase its output of grid services, it should technically and economically analyze the possibility of flexibility utilization as an alternative solution for an investment. The analysis result shall designate a feasible and most cost-efficient option. The following Fig. 3. presents the proposed proof of efficiency test.

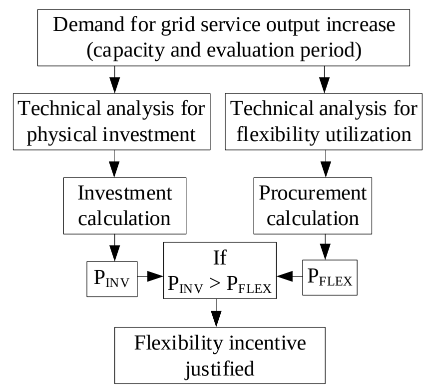

Figure 3. A proof of efficiency test to analyze feasibility and efficiency for grid service output increase. The technical analysis shall first assess feasibility. The investment and procurement calculation provide the service unit price (P_{INV} and P_{FLEX}) information for the given evaluation period. If the flexibility utilization is technically feasible and the most cost-efficient option, then an assignment of flexibility incentive is justified.

If the proof of efficiency for flexibility utilization is verified, then a flexibility incentive should be assigned for the evaluated capacity and period. The NRA should assess the results of the proof of efficiency test. Due to the novelty of proposed regulatory amendment, an ex-ante approach would be preferred to ensure regulatory prudence.

B. Flexibility incentive and efficiency incentive amendments

Flexibility procurement for congestion management comprises from cost factors of procured capacity and activated energy. The redispatching capacity for congestion management shall be procured for both down- and up-regulation [4],[12]. The procured capacity may have alternative use cases as well e.g., balancing, or other reserves. To ensure allocative efficiency, a TSO shall procure timely only the needed amount of capacity from markets. In addition, the volume and price of activated energy are not known explicitly since the need for congestion management is inherently stochastic. To alleviate the risk of unknown market expenses, the costs of flexibility capacity and energy procurement should be excluded from the efficiency incentive (I_E). The approach would be alike to reserve capacity and balance management costs in the current regulation [19].

The proposed amendment to the efficiency incentive passes the operational costs of flexibility from the TSO to society without actually incentivizing flexibility utilization. The rate base of the TSO would remain unchanged, while new staff, processes, and tools for managing the flexibility are required, which increases operational expenses further. Therefore, an additional flexibility incentive is proposed; to incentivize the TSO to utilize flexibility when total welfare is increased, and to establish a fair distribution of welfare to the stakeholders. The TSO would be obliged to run the proposed proof of efficiency test (section III.*A*) to justify flexibility utilization. Only the capacity approved by the test would be assigned to the flexibility incentive. The incentive itself should be based on the procured flexibility capacity i.e., it would be €/MW in metrics. The incentive would increase TSO's fair return, thus the NRA shall define a fair incentive level. The following (3) presents the proposed amendment of flexibility incentive I_{FLEX} to the Finnish regulation methodology (2).

$$R = s \cdot B + O + d + I_{INV} + I_E + I_Q + I_{INN} + I_{FLEX} \quad (3)$$

C. *Welfare distribution with proposed amendments*

The impact of the proposed regulation amendments to the welfare distribution between stakeholders in case of flexibility utilization is analyzed in Table III (comparable with Table II).

TABLE III. WELFARE DISTRIBUTION IN THE AMENDED REGULATION REGIME, FLEXIBILITY UTILIZATION

Welfare Distribution for Different Stakeholders	**Stakeholder**		
	TSO	***Connecting Party (CP)***	***Society***
Costs	Operational costs increase while rate base remains unchanged.	Grid tariff fees. Possible operational costs.	Society (including CP) shall cover TSO costs through grid tariff fees.
Benefits	Flexibility costs are exluded from the efficiency incentive. Flexibility incentive generates profit (subject to the proof of efficiency test).	Early grid connection and rapid start of operational business. Lower grid service unit cost.	No increase in rate base, no depreciations. Lower grid service unit cost. Economic activity increases. Flexibility providers profit.
Summary	Flexibility operational costs are passed through. Flexibilility incentive generates profit. Rate base remains unchanged.	Operational business may begin swiftly. Possible operational costs. Lower grid service cost.	Grid service is supplied at lower unit cost. Total welfare and economic activity increases. Flexibility providers profit.
Regulation methodology	Rate base (*B*) remains unchanged while operational expenses *(O)* increase. No depreciation (*d*) of new assets. Flexibility operational costs are excluded from the efficiency incentive (I_E). Flexibility incentive generates profit (I_{FLEX}).		

IV. DISCUSSSION

The prime driver for the flexibility utilization should be an increase in total welfare. Therefore, the flexibility utilization should be incentivized whenever it is the most efficient methodology to increase grid service output. The proposed regulation amendments in this paper would enable a TSO to provide grid services with a more cost-efficient and diverse portfolio mix without a loss of profit. A portfolio mix of physical investments and flexibility solutions would enhance grid service availability in various time frames. Consequently, the amended regulation should gradually lower the cost of grid services for the whole society while service level improves. On top of the economic benefits, the utilization factor of the existing infrastructure should increase. Hence, the environmental impact of the entire production chain is reduced.

To ensure regulatory prudence, the proposed proof of efficiency test should be subject to ex-ante scrutiny. In addition, an ex-post approach could be used to validate the proof of efficiency test retrospectively. If the ex-post proof of efficiency test is invalid, the TSO should be subject to rectify the inefficiency within a given time limit, otherwise the flexibility incentive should be revoked. In addition, the NRA could control the amount of utilized flexibility by preset quotas or by adjusting the level of flexibility incentive. A higher incentive level would encourage the TSO to actively seek possibilities for flexibility utilization while lower level does the contrary. Moreover, the inherently stochastic operational flexibility costs were proposed to be excluded from the efficiency incentive. However, all the indirect costs (staff, etc.) would still be subject to efficiency incentive. Thus, the TSO would still be pushed to increase its efficiency over time.

This paper handled flexibility utilization as an alternative for an investment to increase service output. The framework of the proposed amendments could fit well for TSO's operational planning to minimize preventive capacity restrictions during planned outages [24]. The proof of efficiency test should be modified for the purpose to compare expected benefits and losses. This possibility should be further studied.

The proposed amendments in this paper are analyzed in the Finnish regulatory regime. However, the amendments could be adopted as well in other countries that utilize similar type of rate of return regulation with incentives, especially in countries that apply the Nordic revenue cap [17] regulation.

V. CONCLUSIONS

This paper provided considerations for economic regulation amendments to incentivize flexibility utilization in the Finnish transmission system. Costs and benefits for a TSO, connecting party and society were evaluated. The analysis showed that beneficiaries of flexibility utilization in the current regulation are the society and connecting party while TSO's efforts to defer an investment would have negative impact on its profit. Therefore, the existing regulation methodology is proposed to be complemented with the following amendments: proof of efficiency test, amendment to the existing efficiency incentive, and new flexibility incentive. The proposed amendments should increase total welfare and establish its fair distribution between stakeholders.

Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739.

References

[1] EU Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').

[2] United Nations. Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015.

[3] GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2020. United Nations Environment Programme; Frankfurt School of Finance and Management; BloombergNEF, 2020.

[4] A. Kuusela, L. Ala-Mutka, A. -J. Nikkilä, S. Peltoketo and T. Rauhala, "Flexible Connection Concept and Planning Studies for its Piloting in a Transmission System," 2022 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe), 2022, pp. 1-6, doi: 10.1109/ISGT-Europe54678.2022.9960358.

[5] International Energy Agency (IEA), "Status of Power System Transformation 2019: Power System Flexibility," IEA, 2019.

[6] IRENA, Power System Flexibility for the Energy Transition, Part 1: Overview for policy makers, International Renewable Energy Agency, Abu Dhabi, Nov 2018.

[7] E. Hillberg et al., "Discussion paper: Flexibility needs in the future power system," Publication was prepared for International Smart Grid Action Network (ISGAN), March 2019.

[8] O.M. Babatunde., J.L. Munda, Y. Hamam, "Power system flexibility: A review," Energy Reports, vol 6, supplement 2, pp. 101-106, 2020.

[9] A. Akrami, M. Doostizadeh, F. Aminifar, "Power system flexibility: an overview of emergence to evolution," Journal of Modern Power Systems and Clean Energy, vol. 7, no. 5, pp. 987-1007, Sept. 2019.

[10] N.E. Koltsaklis, A.S. Dagoumas, I.P. Panapakidis, "Impact of the penetration of renewables on flexibility needs," Journal Energy Policy, vol. 109, pp- 360-369, 2017.

[11] J. H. Zhao, J. Foster, Z. Y. Dong, K. P. Wong, "Flexible Transmission Network Planning Considering Distributed Generation Impacts," IEEE Transactions on Power Systems, vol. 26, no. 3, pp. 1434-1443, Aug. 2011.

[12] S. Peltoketo, A. Kuusela, A. -J. Nikkilä, T. Mäkihannu and T. Rauhala, "Utilization of Flexibility Mechanisms in Regional Outage Planning of Transmission Systems," 2022 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe), 2022, pp. 1-6, doi: 10.1109/ISGT-Europe54678.2022.9960321.

[13] K. Kollenda et al., "Curative measures identification in congestion management exploiting temporary admissible thermal loading of overhead lines," IET Gener. Transm. Distrib. 16, 3171– 3183 (2022). https://doi.org/10.1049/gtd2.12512

[14] M. Lindner et al., "Corrective Congestion Management in Transmission Grids Using Fast-Responding Generation, Load and Storage," 2021 IEEE Electrical Power and Energy Conference (EPEC), 2021, pp. 1-6, doi: 10.1109/EPEC52095.2021.9621491.

[15] Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance)Modern Economic Regulation

[16] C. Decker, Modern Economic Regulation: An Introduction to Theory and Practice. Cambridge: Cambridge University Press, 2014.

[17] T. Kuosmanen, T. Nguyen, "Capital bias in the Nordic revenue cap regulation: Averch-Johnson critique revisited," Energy Policy, Volume 139, 2020, 111355, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2020 .111355.

[18] Cambini, C., Rondi, L. Incentive regulation and investment: evidence from European energy utilities. J Regul Econ 38, 1–26 (2010). https://doi.org/10.1007/s11149-009-9111-6

[19] Finnish Energy Authority, "Regulation methods in the fourth regulatory period of 1 January 2016 – 31 December 2019 and the fifth regulatory period of 1 January 2020 – 31 December 2023 Electricity transmission network operations." [Online] Available: https://energiavirasto.fi/documents/11120570/13078331/Appendix_2_Regulation_methods_electricity_TSO_2016-2023_public.pdf/aa1970fd-1f13-5adb-7472-9516bbda298b/Appendix_2_Regulation_methods_electricity_TSO_2016-2023_public.pdf?t=1582719327000 [Accessed: 28-Feb-2023].

[20] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) (Text with EEA relevance.)

[21] HE 318/2022 Hallituksen esitys eduskunnalle laiksi sähkömarkkinalain muuttamisesta ja siihen liittyviksi laeiksi. [Online] Available: https://finlex.fi/fi/esitykset/he/2022/20220318 [Accessed: 28-Feb-2023].

[22] Averch, H., Johnson, L. L. "Behavior of the firm under regulatory constraint", The American Economic Review, 52(5), 1962, pp. 1052-1069

[23] Entso-e RGN Nordic, Nordic and Baltic Grid Disturbance Statistics 2020. [Online] Available: https://eepublicdownloads.entsoe.eu/clean-documents/SOC%20documents/Nordic/Nordic_and_Baltic_Grid_Disturbance_Statistics_2020.pdf [Accessed: 28-Feb-2023].

[24] S. Peltoketo et al., "Post-fault Activation of Flexible Resources to Manage Regional Congestions Caused by a Contingency during a Planned Outage,", 2023 19th International Conference on the European Energy Market (EEM), 2023.