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# The first step in removing communication and organizational barriers to stakeholders' interaction in Smart Grids: A theoretical approach

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**Abstract.** This research is the first step in scientific work on the formation of organizational and communication system stakeholders` interaction in Smart Grid. This theoretical research studies the cooperation of stakeholders under the logical and meaningful process of initiation, design, implementation, and development of Smart Grid projects. According to researches analysis in this area and the best practice approaches to the development of Smart Grids, a stakeholder` interaction matrix has been formed. The peculiarity of the developed matrix is taking into account the stages and directions (key aspects) of the Smart Grids development. It forms the basis for a systematic analysis of the problem under study. So the designed matrix will be used as a component of the formation of the stakeholders` interaction logical-structural scheme. The development of this scheme is an intermediate stage in modeling the interaction of stakeholders. The research results presented in this paper are the first theoretical step in a multi-stage study of stakeholder interaction.

## 1 Introduction

The transformation of the energy sector is due to new challenges to the energy system functioning. It has several vectors. One such vector is smart grids development. The advantages of this energy system change direction are the formation of a controlled, highly efficient system of production, distribution, transportation, and consumption of electricity. Also, a significant advantage of smart grids is the implementation of the distributed energy generation principle.

The schematic diagram of a smart grid is shown in Figure 1.

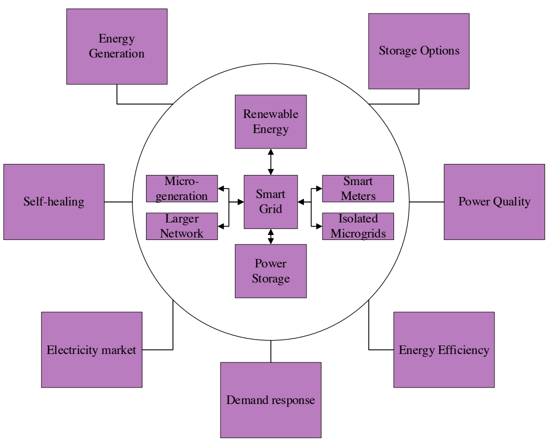


**Fig. 1.** The schematic diagram of a smart grid [1]

There are two components of the smart grid development organization. One element is the formation and implementation of international, state, and regional policies in this area. Another element is the preparation and implementation of smart grid projects. Both components are interdependent. Regulatory acts affect the design and selection of smart grid projects that must meet specific criteria. At the same time, implemented and potential projects that apply for scientific and technological advances and innovations can affect national and international energy policy. New technologies that increase the economic and technical efficiency of smart grids can lead to adjustments or significant changes in the regulatory framework for regulating this area. Thus, the organization of system activities for the development of smart grids requires the coordinated actions of many stakeholders. At the same time, the interaction of stakeholders should take place within the framework of a balanced organizational and economic mechanism. The generalized scheme of stakeholders` cooperation in the process of smart grid development and functioning is shown in Fig. 2 [2]. This scheme proposed by the U.S. Department of Energy.

The formation of a balanced stakeholders` interaction system will solve some related problems. In particular, the activation of drivers for the development of the smart grid will have a positive impact on the level of cooperation in the energy sector, including in the renewable energy area [3]. The potential effect of this is to increase green investment [4].

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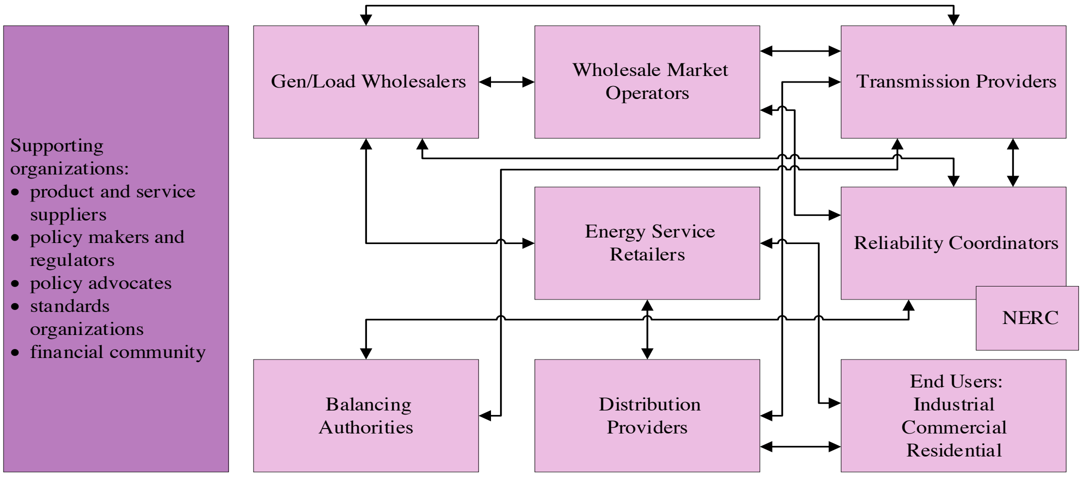


**Fig. 2.** Stakeholder Landscape

Besides, stakeholders` interaction systems can be used to create a model of the socio-ecological-economic development of the administrative territory [5].

## 2. Methods

To the research aims, non-statistical methods, including analysis and deduction, were used. The research is based on the analysis of secondary information, in particular, official smart grids development reports and scientific research in this area. Analysis of the components and processes of the smart grid development was taken as the basis for the design of a stakeholders` interaction system. This approach is appropriate for theoretical research aimed at determining the structure and relationships between stakeholders. This study is the initial stage in the scientific work on modeling the stakeholders` interaction in the smart grids development process.

## 3. Results

Regulations regulate all critical areas of smart grid development. In the EU, in particular, the EU Directives [6-8], European Commission recommendations [9-13] and the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions [14-17] are used for this purpose. These provide the first component of regulating the stakeholders` interaction in smart grids.

Following the smart grid development directions defined by normative legal acts and strategic documents, the next stage is the preparation and implementation of the project. At this stage, there is forming a complex system of relationships between stakeholders. The specifics of the project determine the final list of stakeholders. The mechanism and framework of interaction significantly depend on the algorithm of project preparation and implementation. There is a list of systematic approaches to the organization of smart grid development based on systems for assessing smart grid development [18]. IBM Smart Grid Maturity Model [19-21], EU Smart Grid Assessment Benefits Systems [22], and EPRI Smart Grid Construction Assessment Indicators [18] are the most suitable for systematization of smart grid development. These systems should be selected based on research to compare the evaluation systems of smart grids [18]. The use of these evaluation systems allows us to create a network of indicators. The implementation of these indicators requires the stakeholders` interaction. Thus, there is an opportunity to form a structural and logical scheme stakeholders` interaction during every project stage. However, to develop such a scheme, it is first necessary to identify stakeholders involved in the smart grid development. It is appropriate to take an approach in which the identification of stakeholders will be related to the processes in which they are involved.

IBM Smart Grid Maturity Model allows us to design stakeholders` interaction system. And involve to this system five levels Smart Grid Maturity (Traditional level, Exploring, Investing, Integrating, Optimizing, Innovating) and Smart Grid Domains (Strategy and Regulatory, Technology, Organization, Societal and Environmental, Grid Operations, Value Chain Integration, Work and Asset Management, Customer Management and Experience).

The list of operations (processes, goals, and results) according to this IBM Smart Grid Maturity Model is shown in Table 1.

**Table 1.** The list of operations (processes, goals, and results) in Smart Grid

| Processes/Aims/Results | Code | Level | Processes/Aims/Results | Code | Level |
|---|---|---|---|---|---|
| Developing the first SG vision | A | 0; 1 | Collaboration with external stakeholders | 2R | 4 |
| Support for experimentation | B | 1 | Environmentally driven investments (aligned with SG strategy) | 2S | 4 |
| Informal discussion with regulators | C | 1 | Environmental scorecard/reporting | 2T | 4 |
| Funding likely out of existing budget | D | 1 | Programs to shave peak demand | 2U | 4 |

| Processes/Aims/Results | Code | Level | Processes/Aims/Results | Code | Level |
|---|---|---|---|---|---|
| Initial strategy/business plan approved | E | 2 | Ability to scale distributed generation units | 2V | 4 |
| Initial alignment of investments to vision | F | 2 | Tailored analytics and advice to customers | 2W | 5 |
| Distinct SG set-aside funding / budget | G | 2 | Managing distributed generation | 2X | 5 |
| Completed SG strategy and business case incorporated into corp. strategy | H | 3 | Exploring new sensors, switches, comms. devices and technologies | 2Y | 1 |
| SG governance model deployed | I | 3 | Exploring outage and distribution mgmt. linked to sub-station automation; Safety and physical security | 2Z | 1 |
| Mandate/consensus with regulators to make and fund SG investments | J | 3 | Building a business case at a functional level | 3A | 1 |
| Corp. strategy expanded to leverage new SG enabled services or offerings | K | 3 | Initial distribution to sub-station automation projects | 3B | 2 |
| SG drives strategy and influences the corporate direction | L | 4 | Sharing data across functions/systems and Implementing control analytics to support decisions and system calculations | 3C | 3 |
| External stakeholders share in strategy | M | 4 | The new process being defined due to increased automation and observability | 3D | 3 |
| Optimized rate design/regulatory policy | N | 5 | Integration into enterprise processes | 3E | 4 |
| Articulated need to change: Executive commitment to change | O | 1 | Grid employs self-healing capabilities (optimized rate design/regulatory policy is included) | 3F | 5 |
| Articulated need to change: Culture of individual initiatives and discoveries | P | 1 | Conducting value analysis for new systems and exploring RAM (Remote Asset Monitoring) | 3G | 1 |
| Articulated need to change: Knowledge growing; possibly compartmentalized | Q | 1 | Exploring proactive/predictive asset maintenance and exploring using a spatial view of assets | 3H | 1 |
| Organizing more around operational end-to-end processes and Matrix teams for planning and design of SG initiatives | R | 2 | Developing a mobile workforce strategy | 3I | 2 |
| Evaluating performance and compensation for Smart Grid | S | 2 | Component performance and trend analysis | 3J | 3 |
| Org. is adopting a matrix or overlay structure | T | 3 | Efficient inventory management utilizing real asset status and modeling | 3K | 4 |
| Culture of collaboration and integration | U | 3 | Optimizing the use of assets between and across supply chain participants | 3L | 5 |
| End to end grid observability allows organizational leverage by stakeholders | V | 4 | Research on how to reshape the customer experience through SG and Broad customer segmentation | 3M | 1 |
| Significant processes restructuring | W | 4 | Piloting AMI/AMR | 3N | 2 |
| Collaboratively engage all stakeholders in all aspects of transformed business | X | 5 | Modeling of reliability issues to drive investments for improvements | 3O | 2 |
| Exploring strategic IT architecture for SG | Y | 1 | High degree customer segmentation and common customer experience | 3P | 3 |
| Identifying uses of technology to improve functional performance | Z | 1 | Outage detection at a substation | 3Q | 3 |
| Developing processes to evaluate technologies for SG | 2A | 1 | New interactive products/services | 3R | 3 |
| Tactical IT investments aligned with strategic IT architecture | 2B | 2 | Usage analysis within pricing programs | 3S | 4 |
| Common architectural vision and commitment to standards | 2C | 2 | Customer management of their end to end energy supply and usage level | 3T | 5 |
| IED connectivity and business pilots and Implementing information security | 2D | 2 | Mobility and CO2 programs | 3U | 5 |
| SG impacted business processes aligned with IT architecture | 2E | 3 | Identifying assets and programs within a value chain to facilitate load management programs and identifying distributed generation sources and existing capabilities to support | 3V | 1 |
| Common architectural framework | 2F | 3 | Develop a strategy for a diverse resource portfolio | 3W | 1 |
| Implementing SG technology to improve performance | 2G | 3 | Introducing support for home energy management systems | 3X | 2 |
| Enterprise business processes optimized with strategic IT architecture | 2H | 4 | Redefine value chain to include entire eco-system | 3Y | 2 |
| Real-world aware systems — complex event processing, monitoring, and control | 2I | 4 | Pilot investments to support the utilization of a diverse resource portfolio | 3Z | 2 |
| Predictive modeling and near real-time simulation | 2J | 4 | Integrated resource plan includes new targeted resources and technologies | 4A | 3 |
| Enterprise-wide security implementing | 2K | 4 | Enabling market and consumption information for use by customer energy mgmt systems | 4B | 3 |
| Autonomic computing, machine learning | 2L | 5 | New resources available as a substitute for market products to meet reliability objectives | 4C | 3 |
| Environmental compliance | 2M | 1 | Energy resources dispatchable/tradable, utility realizes gain from ancillary services (e.g., power on demand) | 4D | 4 |
| Renewables program | 2N | 1 | Portfolio optimization modeling expanded for new resources and real-time markets. | 4E | 4 |
| Established energy efficiency programs for customers | 2O | 2 | Coordinated energy management and generation throughout the supply chain and coordinated control of entire energy assets | 4F | 5 |
| Segmented & tailored information for customers — including environmental and social benefits | 2P | 3 | Dispatchable recourses are available for increasingly granular market options (e.g., LMP – Locational Marginal Pricing) | 4G | 5 |
| Programs to encourage off-peak usage | 2Q | 3 | | | |

Each operation in the framework of smart grid development was assigned a code using the letters of the English alphabet. The level to which these operations belong is also indicated.

A list of stakeholders has been identified based on the selected tasks that should be done to smart grid development (Table 2).

Each stakeholder is assigned a digital code. The combination of operation codes and stakeholders makes it possible to trace in which operation at which stage of the project each stakeholder is involved. For example, A1 means stakeholder with code 1 is engaged in process A; 2A3 implies that the stakeholder 3 is engaged in process 2A. The results of structuring stakeholders` interaction according to the processes in which they are involved are shown in table 3.

The list of stakeholders may vary depending on the specifics of the project. It is also true for smart grid development operations.

**Table 2.** A list of stakeholders in Smart Grid

| Stakeholders | Code |
|---|---|
| Project initiator | 1 |
| Public authorities (state government) | 2 |
| Local authorities (local government) | 3 |
| International institutions | 4 |
| Project executor | 5 |
| Public, non-governmental organizations, including international | 6 |
| Research institutions | 7 |
| Project organizations | 8 |
| Financial and credit organizations | 9 |
| Market regulator | 10 |
| Project customer | 11 |
| Gen/Load Wholesalers | 12 |
| Wholesale Market Operators | 13 |
| Transmission Providers | 14 |
| Energy Service Retailers | 15 |
| Distribution providers | 16 |
| End-Users: Industrial, Commercial, Residential | 17 |
| Supporting organizations: product and service suppliers | 18 |
| Shareholders | 19 |
| Territorial community, population | 20 |

**Table 3.** Stakeholders` interaction system

| The Smart Grid Maturity Model` Level | | Strategy, Management &Regulatory | Organization & Structure | Technology | Societal & Environmental | Grid Operations | Work & Asset Management | Customer Management & Experience | Value Chain Integration |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Innovating – Next Wave of Improvements | N2, N10, N11, N12-16 | X1-4, X6-19 | 2L7, 2L11-18 | 2W11, 2W17, 2W18, 2X10, 2X11, 2X12-18 | 3F2, 3F10, 3F11, 3F18 | 3L11, 3L10-18 | 3T11-17, 3U2, 3U4*, 3U6, 3U10, , 3U11, 3U17, 3U18 | 4F9-18, 4G3, 4G10-17 |
| 4 | Optimizing – Enterprise-Wide | L11, M2*, M3, M4*, M6*, M7-10, M12-19, | V2, V3, V4*, V6*, V9, V11-V19, W11 | 2H11, 2I11-18, 2J7, 2J11, 2K7, 2K18 | 2R2, 2R3, 2R4*, 2R6-18, 2S2, 2S3, 2S4, 2S9, 2S11, 2T2, 2T3, 2T4*, T6, 2T10, 2T19, 2U11-17, 2V11, 2V17 | 3E11 | 3K11, 3K17, 3K18 | 3S11-18 | 4D10-17, 4E9, 4E11, 4E18-19 |
| 3 | Integrating – Cross-Functional | H5, H11, I11, J10, K12-18 | T11, U2, U3, U4*, U6*, U7-19 | 2E5, 2E11, 2E18, 2F5, 2F11-18, 2G5, 2G11 | 2P4*, 2P6, 2P11, 2P17, 2Q11, 2Q17, 2Q18 | 3C5, 3C11-18, 3D11, 3D18 | 3J5, 3J7, 3J8, 3J11 | 3P11, 3P17, 3Q5, 3Q11-16, 3R11, 3R18 | 4A11, 4A18, 4B11-17, 4C11, 4C17, 4C18 |
| 2 | Functional Investing | E1*, E5, E9, E11, F2, F3, F4*, F5, F8, F9, F10, F11, G9, G5, G11 | R5, R8, R11, S2, S5, S11, | 2B9, 2B11, 2C10-17, 2D5, 2D11 | 2O11, 2O17, 2O18 | 3B5, 3B9, 3B10, 3B11, 3B18 | 3I5, 3I8, 3I11, 3I18 | 3N5, 3N8, 3N11, 3N17, 3N18, 3O5, 3O7-9, 3O11 | 3X5, 3X7, 3X8, 3X11, 3X17, 3X18, 3Y5, 3Y7, 3Y11 |
| 1 | Exploring and Initiating | A2, A3, A4*, A6, A7, B1*, B5, B7, B8, B11, C1, C2, C3, C5, C8, C10, C11, D1, D5, D8, D9, D11 | O2, O3, O4*, O10, P6-8, P11, P17, Q7, Q8, Q11 | Y7, Y18, Z7, 2A5, 2A7, 2A11, 2A18 | 2M2, 2M3, 2M6, 2M7, 2M17, 2M19, 2M20, 2N11, 2N17, 2N18 | 2Y5, 2Y7, 2Y11, 2Y18, 2Z5, 2Z7, 2Z11, 2Z18, 3A5, 3A11 | 3G5, 3G7-9, 3G11, 3H5, 3H7-9, 3H11 | 3M6-8, 3M11, 3M17 | 3V5, 3V7-9, 3V11, 3V18, 3W7, 3W9, 3W11, 3Z9, 3Z11 |
| 0 | Default level (status quo) | A2, A3, A4*, A6, A7 | | | | | | | |

*optionally

## 4 Conclusions

The formed matrix of stakeholder interaction in smart grids development is the first step to the research of communication and organizational barriers. These barriers should be broken for smart grids projects development and its scaling. In the future, the matrix should become more detailed to include all necessary processes and interactions for different kinds of projects. After that, it will be placed as a base on the logic-research scheme "stakeholder-operation-interaction". Currently, there are different approaches to the development and implementation of energy efficiency projects [23]. Therefore, the use of a logical-structural scheme will reveal the inefficiency of stakeholder interaction. That is, it will identify organizational and communication barriers to break them. Creating a balanced stakeholders` interaction system will help to solve two problems. 1. The formation of a comprehensive mechanism to regulate smart grid development. This is relevant in countries where such a mechanism does not exist. 2. Increasing the efficiency of stakeholder involvement in the smart grids development processes, i.e., the use of hidden reserves to scale energy innovations. This is relevant for countries where a level of smart grid development above average.

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