Implementation of open-source solutions in the energy sector and in the area of renewable energy

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Abstract: **The open-source industry has its independent track record as a part of software science. It has presence in most of industrial sectors. Here is a particular study of the application of open-source solutions in the energy sector as well as the renewables. The recent development of smart grids took enhancement by the open-source solutions. There are needs for dynamic-analysis on the economic effects of implementation of open-source software solutions in the management of the smart grids. In this paper, a new perspective, "implementation of open source in the energy management", is proposed, which defines the levels of conversion. In order to demonstrate the effectiveness of this methodological approach, capabilities of exporting high-technology software solutions were examined, and then previously developed indices of sustainable energy and of economic development of the world were analysed. As a result, the methodological approach for shaping and defining the sustainability zone was determined upon the dynamic-analysis on the development of socio-economic system.**

Index Terms: **open-source software, smart grids, renewable energy, energy storage, sustainable analysis, cost efficiency, index of economic dimension.**

I. INTRODUCTION

Open-source development has become increasingly popular in recent years. Open-source encourages collaborative and transparent program development and promotes unlimited free redistribution of source code to the open audience. The software development process has evolved from vendor-locked, proprietary software into a free to collaborate, open-source model. It commits to sharing knowledge, free redistribution and access to design and implementation of solutions. Open source accelerates changes in the technology sector and enables transition to green energy (Pierce, October 2020).

Funding for open-source software development solutions often takes the form of grants and fellowships prized by government bodies and foundations where there is no conflict-of-interest between the funding entity and the free dissemination of the open-source software products.

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The main idea is the delivery scalable and modular plug-and-play components. Ideally, solutions can be implemented much faster, and be adapted dynamically to evolving energy business models (Hammond, G. E., December 2013).

Open-source solution is transparent for exploration of the source code for improvement and review of the algorithms. In this way everybody has access to the working model. The additional benefit is the opportunity to build own versions, features and capabilities. Bug fixing and development of new features is additional benefit.

II. MODEL OF SUSTAINABILITY

Renewable energy comes from sources or processes that are constantly disposable, but unreliable enough. These sources of energy include solar energy, wind energy, geothermal energy, and hydroelectric power.

Nowadays we are experiencing faster energy transition and it is required even more and more. We are experiencing historical transitions between major energy sources. Most of these shifts lasted over a century or longer and were stimulated by resource scarcity and technological innovations. One of these constantly coming innovation is the rise of the smart grids managed by open-source software solutions. As the energy mix is constantly being enriched by classical and new energy sources, the production of energy evolved significantly.

Consumers have grown to producers, generating and exchanging sustainable solar, wind, and hydro energy. Thus, the open-source software is already a part of that energy production evolution. The new energy model is based on sustainable power sources and is getting more and more decentralized. We can see placed solar panels on their private roofs or small wind turbines in small farms. In all cases end users have more control. Power is not only streaming from power generation sites to the end users, but also from the end users to other consumers.

Individual users and private consumers are starting to generate energy without the control of the energy production and distribution companies. That requires new approach to the power production and balancing the produced and consumed energy.

The smart grids are supposed to be a possible solution. That kind of grid is an information exchange part of the power grid. Smart meters, automation, and demand & supply systems usually are a part of a smart grid. Demand

and supply systems match and switch the power consumption with the power production to integrate renewable energy without additional storage.

Extremely important are the smart grids in the area of renewable energy. According the Karlsruhe Institute of Technology, Germany, as one of most industrialized counties is aiming the climate neutral energy production. That climate neutral and sustainable energy system has its great challenges. Professor Otmar D. Wiestler, President of the Helmholtz Association, says (Wiestler, 2020): "Local, national, and international energy systems have to be switched to renewable energy sources as quickly as possible".

As subcategory of the smart grids are so called mini-grids. Mini-grids can be described as interesting and important midway point between stand-alone and major grid electricity systems. They usually in far areas where is not economically meaningful to connect to large grids due to their isolation or geographical distance. The use of a mini-grid also permits the use of generation technologies that might not be feasible or economical at smaller scale, such as multiple diesel gensets or biomass or small hydro facilities. Micro and mini grids vary in wide range of power to critical infrastructure in cities (hospitals, prisons) or agricultural sites, to providing greener, more reliable energy for universities and commercial and industrial sites.

Climate-friendly transformation requires diverse energy mix and inclusion of different technologies, new architecture and security of the future power grid and integration in the energy system. All power grid components, such as renewables, redox flow storage systems, biogas facilities, or gas turbines for the reconversion of synthesis gas and biogas are composed and integrated together to combine all kind of power supply. In addition, lifecycle-oriented sustainability analyses were made. And that integration gives the leading role of grid management to the open-source solutions. And as a result, in Germany, for instance, in 2019 the share of renewable energy sources in gross power consumption was 42,1%, in 2018 37,8%, according to the Federal Environment Agency.

Another aspect of energy management for more and more invented renewable power generation is the computer modelling. The software simulations can help in planning of power generation capacities, energy transportation and storages. For that computer simulations are taken into consideration also dynamic parameters like time and energy consumption. Karlsruhe Institute of Technology has developed such modeling tools that the Helmholtz Association has recently made available on an Internet open-source and completely free. There are no general standards for computer modelling, but it is used mainly in design and planning of power lines, distributed power plants or future change of the energy infrastructure. The open-source led computer models are used for important decision making. The open-source platforms are quite new for that usage, but they are being constantly invented for scalable projects, realistic data, projects planning and optimization of future energy systems, known also as capacity expansion planning. Software algorithms are available to solve typical optimization problems in the expansion of renewable energy. The software contains also accumulated data records. The interaction of both tools the algorithm and the data storage enable optimal operational and investment decisions within the full range of energy systems and power transmission grids (Jansen, April 2015).

Another use of open-source software is in the direction of Data analyses and demand planning. A report published by the National Renewable Energy Laboratory (NREL), the Renewable Electricity Futures Study (RE Futures), is an interesting research how renewable energy supply can meet the electricity demands of the United States energy consumption over the next 30-40 years. This research studies the implications and challenges of high renewable electricity generation levels varying from 30% up to 90%, of all U.S. electricity generation from renewable technologies and how it will fluctuate, what are the trends (Hanselka, August, 2020). At such high levels of renewable electricity generation, the unique characteristics of some renewable resources, specifically geographical distribution and variability and uncertainty in output.

The cost efficiency is one of the most usable characteristics of the open-source software solutions in the energy sector. Direct cost associated with high renewable generation is comparable to cost estimations of other clean energy mix. The aim is to the improvement in the cost structure and performance of renewable technologies and of course – the reduction of non-meaningful costs. One of the main objectives of an open-source energy system is to reduce total costs by reducing software development costs and facilitating the interconnection between systems. Beside the cost reasons, there are more grounds to save time, resources and human capacity by using the automation in planning the capacity of the grid and increasing the agility.

The open-source solutions generate significant cost savings in the energy sector. The software is available for free use in the form of community supported and improvable projects. Or it could be bought through corporate packages at very tine price, that cover subscriptions for support and software upgrades.

The topic of open data can also be included in the open-source models. Many open-source systems used for modeling, analysis and forecasting are based on so-called open data. In the energy sector, open data can be divided into several categories:

Demand related open data:

- Electricity demand
- Thermal demand
- Transport demand
- Industrial demand

Resources and Potentials

- Weather data and availability of renewable energy
- Wind geographical potentials
- Biomass potentials
- Hydroelectricity potentials

Networks:

- Electricity transmission networks

- Electricity distribution networks
- Gas distribution networks
- Generation technologies:

Power plants

- Generation technology assumptions and projections
- Storage technology assumptions and projections
- End-use technology assumptions and projections

General data:

- Demographic and socio-economic data
- Environmental data and regulations
- Historical data and profiles
- Energy scenarios
- Country-specific targets and policies

And finally, one more, political perspective for the government owned or strongly regulated energy sector. In a few years it will be easy enough to choose open source without any legal or governmental pressure. Open-source solutions should be imposed in all institutions to use of open formats. Any information or data in electronic form should be in a freely documented format so that software and hardware from different machines, systems and manufacturers can communicate free each other with less external intervention. And that is especially true for emerging and developing markets like South-Eastern European countries.

The directives and plans of the European Commission for the future of energy, also known as the "Green Deal", add to the idea of open source, providing companies, organizations and consumers with direct participation to the production of the energy they need. Apart from the conceptual, the support has financial dimensions that seem to be still out of the government's interest, but will be directive implemented sooner or later. The impact analysis is evaluating the possibilities to influence the sectors transport and energy in medium- and long-term perspective by significantly reducing the direct costs by implementing the open-source approach on the infrastructure, middle ware and cloud level.

III. Outcome and Findings

The open-source solutions are providing a flexible model involving the different elements of the system and increasing the resistance against cyber attacks. This approach is giving the possibility to scale the structure and to provide agile vision on the strategic development of the energy and transport companies worldwide. Obtaining the open-source solution in order to boost the business processes and manage the energy streams the companies from these sectors are capable of increased analysis of the consumption, monitoring and control. The addressable market are not only the utilities companies, but also the power generation, the energy transmitting and many more. The sector transport is mainly affected in this context regarding the energy transport electrification – substations, contact line and many more.

Of significant importance is to use the full capacity of the different smart elements of the systems based on the enhanced open-source functionality in order to achieve the maximum impact both to the public buildings and households as well as to the industrial sector and specific infrastructure – public lighting, intelligent traffic solutions and many more.

IV. Conclusion

After evaluating the independent strengths and trends both of open-source software solutions and management of the smart grids, renewable energy production, storage and transportation, it was found that the trend is sustainable and the convergencies will continue. More significant cost and economic effects will be observed as a result of implementation of the open-source software solutions in the energy management amplifying the ecological and institutional effects.

The methodical approach described in this paper enables determining the sustainability zone upon the socio-economic development. Elaborating the measures that would allow maintaining the level of sustainability and predictability for a long period of time.

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