Micro-grid platform based on NODE.JS architecture, implemented in electrical network instrumentation

M Duque¹, E Cando¹, A Aguinaga¹, F Llulluna¹, N Jara², T Moreno³

¹Department of Mechanical Engineering, Escuela Politécnica Nacional, Quito-Ecuador.
²Faculty of Mechanical Engineering, Universidad Politécnica Salesiana, Cuenca-Ecuador.
³Department of Mechanical Engineering, Escuela Politécnica del Chimborazo, Riobamba-Ecuador

E-mail: mauricio.duque@epn.edu.ec

Abstract. In this document, I propose a theory about the impact of systems based on micro-grids in non-industrialized countries that have the goal to improve energy exploitation through alternatives methods of a clean and renewable energy generation and the creation of the app to manage the behavior of the micro-grids based on the NodeJS, Django and IOJS technologies. The micro-grids allow the optimal way to manage energy flow by electric injection directly in electric network small urban's cells in a low cost and available way. In difference from conventional systems, micro-grids can communicate between them to carry energy to places that have higher demand in accurate moments. This system does not require energy storage, so, costs are lower than conventional systems like fuel cells, solar panels or else; even though micro-grids are independent systems, they are not isolated. The impact that this analysis will generate, is the improvement of the electrical network without having greater control than an intelligent network (SMART-GRID); this leads to move to a 20% increase in energy use in a specified network; that suggest there are others sources of energy generation; but for today's needs, we need to standardize methods and remain in place to support all future technologies and the best option are the Smart Grids and Micro-Grids.

Introduction

The electrical network was designed a hundred years ago, its goal was to supply electricity to an specific community for basic needs (radio, illumination and cooking), were with, electric need was low; but, now a day necessity on electricity has grown significantly and our society now depends on it, for this reason the networks that were not prepared to asume and satisfy this needs are lack on efficiency due to their unidirectionality, they do not have a feed back system and also have few interaction with the user. Another motivation is the integration of alternative and renewable sources of energy. The Smart-Grid is an autonomous, efficient and optimum system with the capacity of making decisions that will benefit the user and also the business that generates the service; a Smart-Grid allows the integration between multiple, which can interact between them with the goal of optimizing

¹ To whom any correspondence should be addressed.
the energetic use in micro systems like the Smart-Home, Smart-Car, Renewable Energy, Consumer Engagement, Operation Centers, Distribution Intelligence y Plugins and others that together make a Smart-grid system, improving the efficiency of electricity use. Unlike today’s trend, that suggest that all devices that are connected to a network are under one system that just verify its function but not the quality the Smart-Grid, provides a whole of independent systems interconnected in one network that have the ability of control some processes but with the efficiency for work under one premise ‘Optimization’.

In —‘Figure 1’, we show the Smart-Grid systems reach world wide in 2010; this shows that the utilization of this system is low for some reasons:

1) High costs of governmental installation.
2) Obsolete electrical networks.
3) Low prices on electricity production.
4) The non-existence of penalty for electrical inefficiency (power stealing leak, foulcault flowing etc).
5) The poor effort of the government for brings in this technology.
6) The low stock of the products that work with this technology.
7) The cost of the equipment for its correct work.
8) Complex urban infrastructure.

![Figure 1. Smart-Grid diffusion in the world wide 2010.](image)

From the above, in this paper we will analyse the points (6), (7) y (8).
The —‘Figure 2’— shows the electrical flow in Ecuador in 2011. Of the total or energy consumption in Ecuador, the 66.6% is wasted energy and just the 36% of electricity generation is use, el other 64% is wasted energy for many reasons, among these by energy inefficiency, because we could provide other countries of the same size of Ecuador with the amount of energy we waste; for this reason, we see that this country has potential for carrying this Smart-Grid technology mainly for the recent change on the energy matrix, where is expected to generate more electricity for avoid the importation of it, that in 2006 represented the spending of a billion dollar because of the building of hydroelectrics which have the challenge of generate 8740 megawatts that will be working in 2016.

The incorporation of renewable and alternative energy will demand the availability of microgrids. There is a trend to decentralized energy resources that include homeowners connecting to the grid. With this idea of the new energy matrix, Ecuador must consider to have a system that minimize energy losses, which affects directly for sale energy to other countries; in conclusion, through optimize the use of electricity in every home, the capacity for export it will increase.

One way to develop the micro-grid in Ecuador is by creating a self sustaining basis with the purpose of build infrastructure that support systems that are based on in Smart and Micro Grids, that work with modern technology such as NodeJS, IOJS and Django; with this our main goal is to have an place in the word in this area.

Ecuador has initiated a transformation process model, from being an exporter of raw material to become a society that will export products based on the knowledge and the biodiversity of the change of the productive matrix that will provide the product high added value; according to the government: Ecuador is betting to change its production model in a long term, where the change of imports and exports, along with innovation, science, technology and knowledge will allow to give a massive step in to the future.

Even though in Ecuador Smart-Grids systems could be implemented, this kind of technology is available the most of the time for first world countries, which have a bigger economic power than countries that have a poor economy. In the same way, business that owns this kind of technology will create technological dependency due to they are owners of the systems that also impose policies that are beneficial for their industry but not for the industrial development of the country.

When the NodeJS appears in a middle of 2011, change the web world, because this can serve more 64000 connections in a same time, this more than java and PHP, where the users number it’s the approximately 4000 concurrent connections, for another hand, NodeJS use the benefits of a v8 engine of the Google Chrome, and plus the asynchronous power, the meaning of this, NodeJS can be change.
in a real time all variables or independently each ones of them, without need recharge the browser, this let the NodeJS are the really tool for develop our purposes.

**Objective**

a. Design microgrid architecture and controls.

b. Design a Communications protocol for microgrids.

c. Lay the groundwork for the standardization of control systems for Micro – Grids.

2.1. **Specific objective**

I. Design a control platform for Micro -Grid systems, with components of low cost, applied to the basic measurement variables, for Internet access.

II. Provide a network tool that can monitor and control signals processes through the analysis of physical variables.

III. Use current technologies such as JavaScript, Python, Django, IOJS and NodeJS for the development of the platform, leveraging the benefits of real-time telemetry and interconnectivity that these have.

**3. Methodology**

In first place, this proposal includes the development and implements of a web platform of a virtual system for perform the instrumentation and measuring of electrical, climatic and physical variables in order to have a better distribution of the micro-girds in Ecuador. In second hand, I suggest the utilization of low cost devices, like a Raspberry pi, Arduino and others components open hardware that could withstand the idea that I gave above; both proposals would make up a basic design for the development and implementation of the Micro - Grid.

The application will have the following peculiarities:

a) Local and two-way communication with a prototype (hardware) for the control and automation

b) An interface where the user can create an instrumentation panel for monitoring critical variables (Temperature, humidity, electric current and voltage and more).

The control devise must do four basic duties: acquisition, analysis, data reporting and monitoring; this devise has the chance of add more functionality without extra money spending, but it’s not all to will doing, the most important, this can be take a decisions on critical moments, connect/disconnect any device in a real time, with intentionally for cause more benefits to electrical network.

From computers use was essential in measuring the analysis of such data in histograms that allows to have control and a feedback of the process, but this was not only the advantage of using virtual instrumentation; now a day we can integrate this technology with different industrial equipment PLCs, inverters, among others, transforming complex manual processes into automated processes, where it is preponderant the use of virtual instrumentation as a principle of decision-making, minimizing the human errors improving quality of peoples live.

Flexibility, low maintenance cost, reusability, customizing each instrument, the fast introduction of new technologies, low cost per channel and function are some of the benefits of the Smart-grid integration. Mainly the greater impact it has on the energy industry was the emergence of the terms "flexible automation" which involves synapses between different elements that are acting on a grid and can have an impact depending on the behavior of different variables.

Next we show the architecture for the platform:
Figure 3. Platform Architecture.

The —‘Figure 3’, we present the APP; this platform allows: Connect to device, view the variables; personalize the dashboard, determinate behavior the micro-grid shield. All the app is programmed in NodeJS and Django, are disposed in internet; when the user sign in to the app, he can find the all devices are connected in your net, for example: in one home have three micro-grids (i.e. roof, devices, and smart-car) are all plug in to the micro-grid shield net, each one are controlled independently but the setup is configuring through the app. The user can view in the dashboard variables (volts, currents) for each devices global or independent and in another hand, he can do turn on/off the energy flow.

| APP      |                  |
|----------|------------------|
| OS       | Multiplatform    |
| Application Server | NodeJS IOJS Django |
| Languajes | JavaScript Python C#, C++ |
| Frameworks | Mongoose Express Angular |
| Data Base | MongoDB Rethink |
| Dispositives | SmartPhones Tablets PC |

Figure 4. Components of APP.
The —‘Figure 4’, contains all characteristics have the app, if Django and NodeJS are not compatibility but both have a characteristic target in to the APP, for example NodeJS and IOJS handles to all visual in app, while Django to do the signals process; the user never see the difference between three servers.

![Figure 5. Micro and Mini-grid shield Architecture.](image)

The micro-grid shield allows data acquire signals for the process, for example consumed current, temperature and the lux for the any areas, too it can power on/off any devices and finally and more important are a big capacity for management the switching electric flows, between consumed and produced energy in this way, the micro-grid together conform a mini-grid —‘Figure 6’, interconnected among all through internet way, and all information are send to the app, where the user can manage the behavior the each ones. The diagram —‘Figure 5’, represent are components have the shield architecture.

![Figure 6. Mini-Grid Architecture.](image)

The Mini-Grid are conformed by many micro-grids set, this behave like a network, where all information send to cloud through Internet for the app, like the picture above —‘Figure 6’.
When the Mini-Grid produces more electricity than consumed, the behavior of this are allows the flow energy to Mini-Grid to electrical network.

Many sets of Mini-Grids are calling Cell, all interconnected Internet way. We hope in the future this system allows take more benefits by increasing breakthrough in Ecuador, this solve the 20% to 30% the not-benefit electricity.

Special Regards

Our special appreciation to CEDIA (NATIONAL RESEARCH AND EDUCATION NETWORK OF ECUADOR) CEPR A 2015 for the cooperation for the investigation.

Examples taken from published papers:

[1] Academia J, Lorandi Labs 2011 Los Laboratorios Virtuales y Laboratorios Remotos en la Enseñanza de la Ingeniería. Ed.11, Vol 4
[2] Acción pedagógica, Vol 11, Nº1/2002. Rafael Chacón Rugeles, La instrumentación Virtual en la Enseñanza de la Ingeniería Electrónica, pp. 74-84.

[3] F. J. Quiles, J.I. Benavides, A. Moreno, R. Llamuza, J.C. Garcia, M. A. Ortiz, Unidad Docente Arquitectura de Ordenadores, EU. Politecnica, 14004 Cordoba. Puesto De Instrumentación Virtual Digital.

[4] V Congreso de la Sociedad Cubana de Bioingeniería, Habana 2003, A. Adan Vidal, F. Fernández Pérez Terán, A. Calle Herranz, E. Valdés Zaldivar. Estrategia para una instrumentación virtual de bajo costo con aplicaciones médicas.

[5] G. León, A. Aguinaga, 2011 Simulación de control y monitores vehicular usando tecnología GSM como medio de transmisión. Escuela Politécnica Nacional. ISBN 978-9942-07-048-7.

[6] Aguinaga, C. Ávila, E. Cando; 2014 A Multi-layer based architecture for the development of an open source CAD/CAM integration virtual platform. 3th International Conference on Mechanical Engineering and Mechatronics ICMEM 14, (Praga República Checa). World Academy of Science Engineering and Technology. ISSN 20103778, 2010376X

[7] Jason Stamp, Sandia National Laboratories, 2014, Microgrid Design Tools (MDT), 2014 Smart Grid R&D Program Peer Review Meeting.

[8] Michael Stadler, Lawrence Berkeley National Laboratory, 2014, Microgrid design toolset (MDT) development, 2014 Smart Grid R&D Program Peer Review Meeting. (Oak Ridge), TN 37831-6070

[9] Department of energy, USA 2014, The future on the grid, envolving to meet american’s needs. No. GS-10F-0103J, Subtask J3806.0002.

[10] U.S. Department of Energy Office of Electricity Delivery & Energy Reliability 2012, Smart Grid Research & Development, Multi-Year Program Plan (MYPP), pp. 6 -22.