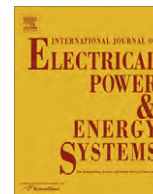




Contents lists available at ScienceDirect

## Electrical Power and Energy Systems

journal homepage: [www.elsevier.com/locate/ijepes](http://www.elsevier.com/locate/ijepes)

## The future of low voltage networks: Moving from passive to active

R.P.S. Leão<sup>a,\*</sup>, G.C. Barroso<sup>b</sup>, R.F. Sampaio<sup>a</sup>, J.B. Almada<sup>a</sup>, C.F.P. Lima<sup>a</sup>, M.C.O. Rego<sup>a</sup>, F.L.M. Antunes<sup>a</sup><sup>a</sup> Federal University of Ceara, Electrical Engineering Department, Caixa Postal 6001 – Campus do Pici, 60455-760 Fortaleza, CE, Brazil<sup>b</sup> Federal University of Ceara, Physics Department, Caixa Postal 6001 – Campus do Pici, 60455-760 Fortaleza, CE, Brazil

## ARTICLE INFO

## Article history:

Received 10 July 2010

Received in revised form 8 June 2011

Accepted 12 June 2011

Available online 16 July 2011

## Keywords:

Small size distributed generation

Low voltage producers

Policies

Regulation

Renewables energies

## ABSTRACT

The growth of energy consumption, the ever extensive use of conventional fossil fuels from exhaustible resources and concerns about the environment have led to the development of sustainable renewable energy as a necessary global requirement. Today, the trend in the electrical sector is the generation of electrical power at low voltage. Distributed generation at low voltage enables consumers to contribute to the country's energy mix system without large investments by governments. This means that dwellers are able to produce and inject electrical power into the grid thus enjoying the status of energy producer and also reducing the burden on the national electrical grid system. In order for this system to produce high quality energy in a safe and coordinated manner, stringent health & safety and technical measures must be implemented. Moreover, such systems require strong legal support and well-established contracts. Technical training of personnel, implementation of well established planned/corrective maintenance systems and electrical spare part availability are also crucial to the reliability and long term operation of such systems. The aims of the paper are to present the basis for development of renewable energy for household usage in countries such as Germany, Denmark, Spain and Brazil, in terms of technical requirements for electrical generation and grid connection at low voltage. In Brazil about 70% of the electricity comes from hydropower and around 50% of its automobiles run on renewable biofuel, which results in a low per capita emission. The country however faces some tough barriers to overcome in order to implement household generation from renewable sources. These will be discussed in due course.

© 2011 Elsevier Ltd. All rights reserved.

## 1. Introduction

Today, the demand for electricity is growing all over the world, resulting in a steady demand to further increase power output capacity. In numerous countries worldwide, people still live without electricity and therefore require specific answers to technological advancement issues. Some emerging countries are experiencing an increase in the standard of living, resulting in replacement of other form of energy by electricity and thus there is a gradual increase of energy consumption. On the other hand, in developed countries with high-energy consumption, despite the incentives to save energy at the end user, new loads are envisaged like plug-in electric vehicles. The meaningful growth of distributed power generation from renewable energy sources is expected to meet the electricity demand increase in the years to come.

Low voltage electrical networks supply the vast majority of electricity customers. Although not too evident at the moment, it

is believed that the generation of electricity by consumers connected at low voltage will have an important role to play in the near future whereby consumers will assume a new condition moving from passive to active players. Whereas the essential condition of an active player is the access to the producer state, the basic roadmap to move to this new scenario goes through a five-stage process: to adopt a simplified system for accessing the distribution network for micro producers; to provide producers credit and favorable rates of return on investment; to establish standards governing the appropriate use of private owned sources connected to the distribution network; to promote mass manufacture of energy sources products along with skilled labor; and finally to endorse stable and long-term policy and program for the establishment of the market.

So far the distribution system has been a passive means to pass power from large and centralized sources to customers. The development of privately owned generators creates changes to a two-way flow of electricity and information and for end-users to participate in a transparent liberalization market, able to react on time varying price signals [1].

For the growth of electrical power production at low voltage, several European countries like Germany, Denmark, Spain, with political support, have enacted new rules for regulating the household electricity production. Countries like Greece and Portugal

\* Corresponding author. Tel.: +55 85 3366 9576.

E-mail addresses: [rleao@dee.ufc.br](mailto:rleao@dee.ufc.br) (R.P.S. Leão), [gcb@fisica.ufc.br](mailto:gcb@fisica.ufc.br) (G.C. Barroso), [rfurtado@dee.ufc.br](mailto:rfurtado@dee.ufc.br) (R.F. Sampaio), [janainaalmada@hotmail.com](mailto:janainaalmada@hotmail.com) (J.B. Almada), [carlosfelipepl@hotmail.com](mailto:carlosfelipepl@hotmail.com) (C.F.P. Lima), [marcoscesar.or@gmail.com](mailto:marcoscesar.or@gmail.com) (M.C.O. Rego), [fantunes@dee.ufc.br](mailto:fantunes@dee.ufc.br) (F.L.M. Antunes).