Executive Summary

VRE Integration

The study presents guidelines related to synthetic inertia as a anacillary service, covering technical aspects and international experience.

August 11, 2021

Analysis of technological alternatives that provide security services to the National Electric System

August 11, 2021

Programa de Energías Renovables y Eficiencia Energética en Chile

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Por encargo de:
Ministerio Federal de Medio Ambiente, Protección de la Naturaleza y Seguridad Nuclear
de la República Federal de Alemania

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The document is framed in the incorporation of dynamic inertia requirements and frequency control based on the levels of dispatch of variable and renewable energies for the electricity supply projections carried out by the Ministry of Energy, for Long-Term Electricity Planning (PELP) process, that guides the expansion of the transmission, and the Transmission Expansion Proposals carried out by the National Electric Coordinator. The study is made by Advanced Center for Electrical and Electronic Engineering (AC3E) of Federico Santa Maria Technical University commissioned by the project "Decarbonization of the energy sector in Chile" of the GIZ 4e project.

Electricity systems nowadays have the participation of synchronous generators and variable renewable energy resources, mainly solar and wind. Those renewable sources are connected to the grid through inverters based on power electronics and their traditional mode of operation is to monitor the grid to support the operation of synchronous generation. In the future, it is expected to use a greater penetration of renewable energy sources, without this leading to network stability problems. Given the reduction of the conventional inertia of the electrical system as a consequence of a low share of synchronous or rotary generation. Due to this, the delivery of virtual inertia by renewable sources based on inverters, produced by means of the control algorithm implemented in its inverter connected to the grid, arises as a alternative solution. This allows these sources to act in front of the grid as synchronous generators (through emulation), maintaining, and even improving (through fast frequency control), the stability of the system and allowing a greater penetration of non-synchronous renewable generation.

This report presents technical and commercial aspects related to the implementation of virtual inertia as a security service to electrical grid, starting with the theory of this concept that includes a review of the mode of operation of grid-connected inverters, principles related to synchronous generation for the delivery of virtual inertia, comparison between adaptation strategies for renewable energy sources and controlled methods or implementation algorithms. The delivery of this service in other countries shows that is it considered a current solution to face stability problems. It is also made an analysis of the relevant information get from international projects to estimate technology costs and to estimate inertia levels delivered by investors. Future challenges that this solution can face are identified and the development of grid-forming inverters at an international level is analyzed, emphasizing implementations, regulations and standards that allow this mode of operation of power converters to deliver virtual inertia to the network. Finally, it is made and identification of storage units, such as solar concentrators that take part in complementary frequency services.

The concept of inertia and virtual inertia is not considered a complementary service in the current regulation in Chile, which motivates the international review around markets to find out proposed solutions.

The analysis of international experience focuses on electricity markets in countries like Ireland, England and Australia, whose electricity systems face similar conditions to Chile, where there is a high penetration of renewable energies, and the policies aim to have an energy matrix with low emissions of carbon. Ireland focused its work guidelines on the development of the DS3 program which allowed the implementation of new security services, together with the creation of scalar factors which seek to enhance the payment of said services that provide added value to the final consumer. From the UK market, their efforts have been in line with the restructuring of their frequency services which seek to encourage participation in all types of technologies and create competitive environment for their participation, in addition to proposing test markets to create services of stability, that seek recompense inertia. Finally, Australia, which of the three countries is the one with the least problems of inertia, is carrying out work to be able to manage the frequency in contexts of low inertia, the incorporation of distributed energy resources for complementary frequency services and regulatory changes that allow bidirectional resource sharing.

Finally, given the connection of renewable projects that are connected to SEN and the possibility of exceeding their renewable penetration goals, the recommendations are focused on technical and commercial aspects, that can be used to be considered considering the need to structure a design of market, which may include the incorporation of virtual inertia as a complementary service and a possible solution to stability of electrical network problems in addition to other types of technologies that are also sustainable.

Edition:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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Intellectual Property Registry. ISBN: 978-956-8066-26-0. First digital edition: August 2021

Citation:

Title: Analysis of technological alternatives that provide security services to the national electricity system
Author(s): GIZ, Ministerio de Energía, AC3E
Review and modification: Nataly Montezuma, Esteban Utreras, Alex Santander, AC3E
Edition: Nataly Montezuma, Esteban Utreras.
Santiago de Chile, 2021.
169 páginas
Energy - Synthetic inertia - Storage - Carnot Battery - Power electronics - Electricity Market

Clarification:

This publication has been prepared on behalf of the project "Decarbonization of the Energy Sector in Chile" implemented by the Ministry of Energy and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH within the framework of intergovernmental cooperation between Chile and Germany. The project is funded through the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Protection and Nuclear Safety - BMU. Notwithstanding, the conclusions and opinions of the authors do not necessarily reflect the position of the Government of Chile or GIZ. In addition, any reference to a company, product, brand, manufacturer or other similar in no way constitutes a recommendation by the Government of Chile or GIZ.

Santiago de Chile, August 2021

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