# GRID FLEXIBILITY 4 CHILE

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## ABSTRACT

*Demand Response (DR) is a mechanism that provides financial incentives to facilities who agree to reduce electricity demand, typically for short periods, in response to grid signals, when the electric grid needs support (to prevent a grid congestion, for instance).*
*It can be used during periods of peak energy use or grid emergencies, or also to prevent them, in order to reduce the system peak, stabilize grid frequency and reduce the dependency of fossil fuels. It can also contribute to make easier the integration of renewable energy sources in the power grid, thanks to the increment in operation flexibility obtained.*
*This paper shows the Grid Flexibility 4 Chile project, a lighthouse project focused on improving power system flexibility through DR, which provides a mechanism to modify power demand in response to grid signals using OpenADR communication protocol.*

## INTRODUCTION

The power system is currently becoming more and more complex. Some reasons are the increasing presence of distributed energy resources (DERs), e.g., renewable power generators [1], [2]. This aggregation of new elements in the power grid constituted which is usually called the Smart Grid (SG) [3], [4]. Moreover, electrification growth (i.e. electric vehicles, heating and cooling etc.) and the service quality exigence for the power system are creating new challenges, in which to maintain grid stability is one of the key issues.
This complexity totally changes the power environment, so it is urgent to enhance techniques to manage the whole power system and solve faults and improve operations. This managing also implies consumption control, which is one of the main indicators of the state of the grid[5].
This situation has caused the appearing of new paradigms that can potentially deal with this increasing complexity, as the Demand-Side Management (DSM)[6]. A specific technique considered in this category is the demand response[7].
Demand Response (DR) is a mechanism that provides financial incentives to facilities who agree to reduce electricity demand, typically for short periods, in response to grid signals[8].
The use of these grid signals constitutes a powerful tool to modulate customer consumption in multiple situations:

- During periods of peak energy use, grid emergencies or to prevent them
- To reduce area dependence on imported fossil fuels for power generation
- To assist in accepting more renewable energy onto the grid and into homes and businesses
- To keep the grid stable, reliable, and running efficiently
- As can be seen, this paradigm brings advantages to both sides, the utility and the customers.

On the one hand, the utility benefits from the power consumption modulation ability, in order to make a better management of the power generation.
Furthermore, the customers receive a bill reductions adapting their consumption and becoming more cost efficient.
Therefore, DR constitutes a Win-to-Win strategy.
Notwithstanding, one of the main barriers that bring difficulties to the use of the DR is precisely that it is a completely new philosophy. For this reason, the customers usually do not know it, so it could cause some reticence when the company offers this type of contracts, and even the utility could have some doubt about what type of DR program (incentive value, power reduction solicited, etc.) would be better to apply.
Another difficult of applying DR is the one related with the data availability and their treatment. As was explained before, DR consist of sending a signal to suggest the customer to low their consumption. Of course, this means the utility must maintain a complete monitoring of how the consumption of every customer change. These operations require a complete infrastructure of measurement and monitoring. Fortunately, a lot of countries (being Chile amongst them), are currently deploying new Smart Meters networks, so this process is much simpler than with the old meters.
Having into account all these difficult and the potential advantages of DR techniques, ENEL, with the support of EPRI, found necessary the creation of a demonstrator for DR techniques, making easier their future application. In this context, the project GridFlexibility4Chile emerged.
Its overview, objectives and tasks are explained in the next section.

## PROJECT SCOPE

The GridFlexibility4Chile project is a lighthouse project focused on improving power system flexibility through DR, that provides a mechanism to modify power demand in response to grid signals using OpenADR (Open Automated Demand Response) communication protocol (supported by the OpenADR Alliance).

The principal objective is the installation of an OpenADR technology demonstrator for enabling Distribution System Operators (DSOs) to harness the benefits of end-users demand flexibility. It will make easier the desired integration of DR philosophy into the power system, having into account that customer approbation is a fundamental part when tackling such a big operation change.

The activities are divided into two main phases:

- Phase 1: Technology demonstration of a DR event in the Smart Grid Building at Santiago de Chile using Open ADR standard protocol. This phase has just finished in 2018.
- Phase 2: Technology demonstration of DERs management (PV, EVs, storage, others) for grid operations and services, testing a Capacity Bidding Program (CBP) in the Enel Smart City Building at Santiago de Chile, using existing and new technologies to be deployed in the site. This phase will start in 2019. During this phase is possible to select other types of services (use cases).

The main objectives and key outcomes expected for both phases are described next:

- Phase 1: Test OpenADR protocol by sending OpenADR 2.0b signal from a simulated DSO side to turn off heat pump / resetting room temperature set point during a DR event (triggered by DSO)
- Phase 2: New strategies, use cases and technical requirements for DR and DER integration, leveraging on smart grids assets, such as smart inverters, energy storage and other controllable loads

The phase 1 had as a result the installation and test of a DR infrastructure, which are described in the next section.

## DEPLOYMENT

The project has been deployed over the Enel Smart Grid Building (SGB), a modern building located in the Business Park of Huechuraba in Santiago de Chile (Chile).

This building pretends to be a complete demonstrator of power system new technologies, showing the potential of Smart Meters (which are already being deployed in Chile), renewable energies and electric vehicle grid integration, and Flexibility programs possibilities (DR, DER management etc.).

*Figure 1: Enel Smart Grid Building (Santiago de Chile, Chile)*

This building has solar generation (Figure 1), electric vehicle charger (Figure 2), inverters, and a whole set of controllable loads, such as the climatic and light installation.


*Figure 2: Intelligent electric vehicle charger*

### OpenADR Protocol

OpenADR is a standard communication protocol oriented to send and receive DR events and related information (such as priority, availability, event schedules, measurements, prices, etc.) [9].

Its architecture consists of two basic elements, the Virtual Top Node (VTN) and the Virtual End Node (VEN). The VTN (commanded by the utility) is able to order when an event have to start and its characteristics (having into account the customer information, their availability and the type of DR program they have). The VEN (which is situated in the customer/aggregator side) receives the event, prices information (if needed) and send necessary information to the VTN.

Considering that this is a specific protocol for DR, it was the selected to be applied in this project.

### System architecture

The proposed architecture during the phase 1, already completed, is exposed in Figure 4.

On one side, the utility side manages and sends the events. This management is conducted by means of a Demand

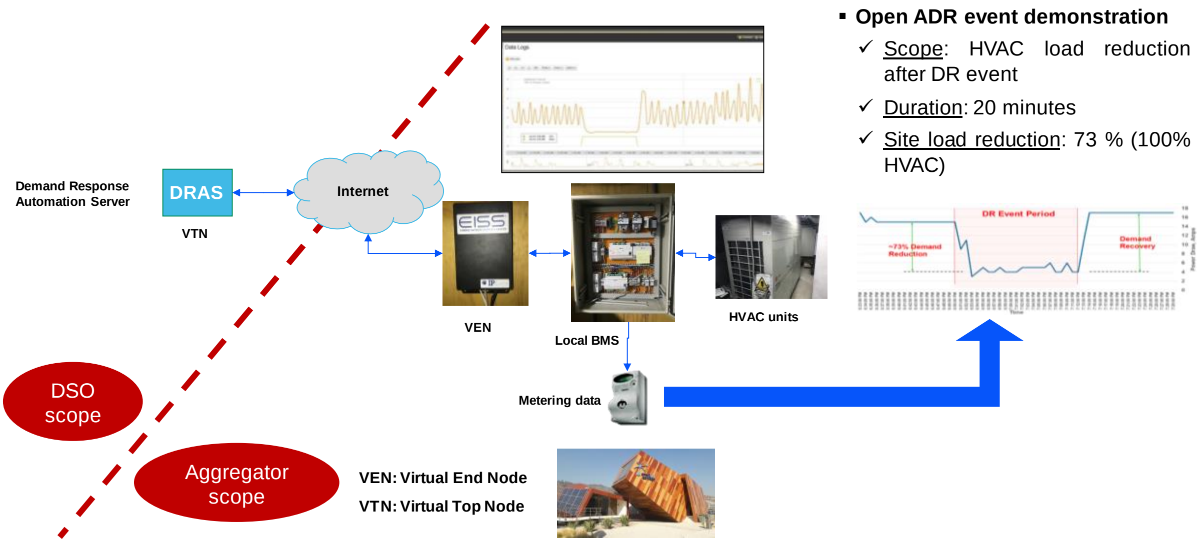


*Figure 4:Phase 1 description chart*

Response Automation Server (DRAS), acting as VTN, which confirm that all the events respect the contract conditions accorded with every customer (or the aggregator). This system is physically located in the USA and has been operated by EPRI.
The event signals are sent through the Internet to the customer/aggregator side (the Smart Grid Building), where the signal must be received (by the JaceBox, a commercial VEN), interpreted (by a Local Building Management System, BMS) and then executed (the BMS gives the orders to all the other controllable systems).
The main controllable load in the building is the Heat, Ventilation and Air Conditioning (HVAC) system.
As it was explained before, a DR application also needs a complete data acquisition and monitoring system. To accomplish this requirement, the installations of the building are connected to the BMS, which continuously collect the power consumption, generation and other variables (as the indoor temperature and conditions).
This BMS was designed by TRANE using a Tracer. Its interface can be seen in Figure 3.

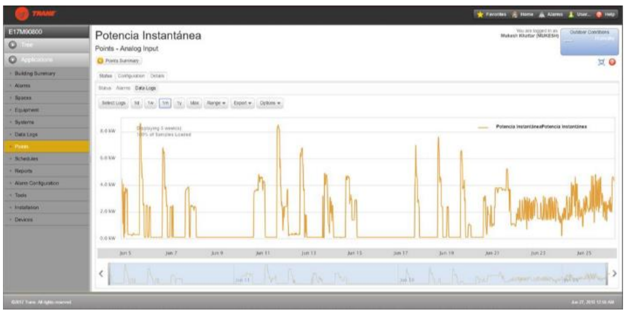


*Figure 3: BMS interface*

These datasets allow to perform analysis aimed to optimize the event configuration and get feedback about how to improve the system.

## RESULTS

This section exposes an example of a real use of an event, and how it is affected to the global power consumption of the building.
The Figure 5 describes the global HVAC system power consumption: before (1), during (2) and then (3) a DR event performed 27th jun. (winter in Chile).

During the initial phase (1) we can see a “normal” consumption pattern, typical in a HVAC system. During the DR event (2), 2 hours long, the system reduces its consumption, both peak and average, about 70%. Once finished the event and about during 30 min, the system presents a typical consumption bound, with a growth of approximately 30% compared to normal conditions.


*Figure 5: Consumption reduction during a DR event*

This result clearly shows how DR event can be used to provide grid flexibility, modulating the customer consumption, which is useful to reduce peak values (i.e. grid congestion), reduce dependency of non-renewable energy sources (i.e. shifting to renewables), and typically used in fast-response power centrals, improving grid stability and quality of service.

## FUTURE WORKS

For the second phase of the project, DER management for the DSO and setting, testing a CBP program will be conducted, using the current infrastructures and new assets to be deployed. This CBP is a good example of a DR program that can be implemented with real customers.
The test of its behaviour and the specification of its characteristics (such as event duration, load reduction value, etc.) is crucial to integrate this type of program in the real power system, managed by the DSO.
Other types of DER services (use cases) will be evaluated. The activity breakdowns as follows:
Task 1: Use cases definition:

- Back-up power
- Reliability (back-tie) services.
- Voltage support, harmonics compensation etc.
- Resiliency/microgrid/islanding.

Task 2: DER selection and sizing.
Task 3: Critical review of control systems, data exchange and communication protocols.
Task 4: Review interconnection requirements for the DER selected.
Task 5: Technology selection, procurement, installation and integration.
Task 6: Use cases implementation and testing.

## CONCLUSIONS

Nowadays, the use of new techniques to become the grid more flexible is an unavoidable task when managing the power system due to its rising complexity. In this environment, the DR has appeared as a powerful tool to regulate the consumption profile, proving grid flexibility mechanisms for the DSO operations.
Due to this, the project GridFlexibility4Chile was set, with the objective of creating a demonstrator of how DR can be applied, showing its potential for grid management purposes. The project is now starting its second phase, where a deeper use of DR techniques and DER management will be performed using the installations and knowledge gain during the first phase.

## REFERENCES

[1] S. Kakran and S. Chanana, "Smart operations of smart grids integrated with distributed generation: A review," *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 524–535, 2018.

[2] E. Baldwin, V. Rountree, and J. Jock, "Distributed resources and distributed governance: Stakeholder participation in demand side management governance," *Energy Research & Social Science*, vol. 39, pp. 37–45, 2018.

[3] M. Kezunovic, J. D. McCalley, and T. J. Overbye, "Smart Grids and Beyond: Achieving the Full Potential of Electricity Systems," *Proceedings of the IEEE*, vol. 100, no. Special Centennial Issue, pp. 1329–1341, May 2012.

[4] H. Farhangi, "The path of the smart grid," *IEEE Power and Energy Magazine*, vol. 8, no. 1, pp. 18–28, Jan. 2010.

[5] E. Personal, J. I. Guerrero, A. Garcia, M. Peña, and C. Leon, "Key performance indicators: A useful tool to assess Smart Grid goals," *Energy*, vol. 76, pp. 976–988, 2014.

[6] A. Mohsenian-Rad, V. W. S. Wong, J. Jatskevich, R. Schober, and A. Leon-Garcia, "Autonomous Demand-Side Management Based on Game-Theoretic Energy Consumption Scheduling for the Future Smart Grid," *IEEE Transactions on Smart Grid*, vol. 1, no. 3, pp. 320–331, Dec. 2010.

[7] P. Palensky and D. Dietrich, "Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads," *IEEE Transactions on Industrial Informatics*, vol. 7, no. 3, pp. 381–388, Aug. 2011.

[8] S. Althaher, P. Mancarella, and J. Mutale, "Automated Demand Response From Home Energy Management System Under Dynamic Pricing and Power and Comfort Constraints," *IEEE Transactions on Smart Grid*, vol. 6, no. 4, pp. 1874–1883, Jul. 2015.

[9] T. Samad, E. Koch, and P. Stluka, "Automated Demand Response for Smart Buildings and Microgrids: The State of the Practice and Research Challenges," *Proceedings of the IEEE*, vol. 104, no. 4, pp. 726–744, Apr. 2016.