

Case Study session 4

Improving performance through digitalization processes at Enel distribution Chile

Session Content:

- Context
- Improving Reliability
- Smart Meter Implementation
- Customer Connection and Distributed Generation



Speaker:

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Solution Optimization

Enel, Chile

Context – Enel Group



Vision

We believe that by working together we can create a new energy era in which the world can become more sustainable

Countries

29

Our presence around the world

Power lines

2

Million kilometers in our distribution network

Total capacity

88.2

GW of total capacity

Renewables

60.1

GW of capacity from renewable sources

Investments

37

Billion euros allocated for assets and technologies in our 2023-2025 Plan, from our own capital and that of third parties

Context – Santiago of Chile



General Data

- Region Population : 8.367.790¹
- GDP: 286.176 M€ (Var: 2,4%)
- GDP/capita²: 14.681€

Government Main Topics

- Long-term climate strategy 2050
- Metropolitan Mobility Plan for 2030
- National Green Hydrogen Strategy of Chile

(1) Projection Central Bank Chile

(2) No. 56 in Ranking of the 196 countries that publish PIB

33
Municipalities
served

2 M
Customers

14 TWh
Energy

2.105 km²
Concession
area

17666 km
Distribution
Networks

Context – Chilean Regulatory Framework



- Chilean regulation is divided into three discrete segments: generation, transmission and distribution.
- All of them are fully run by private companies, which invest in the necessary infrastructure according to each segment's regulatory scheme



Generation

Chile has an open and competitive generation market based on free market rule

Transmission

Based on centralized planning by the regulator, and tendered to private companies

Distribution

Natural monopoly remunerated through the calculation of an efficient company complying with a defined quality standard

Improving Reliability

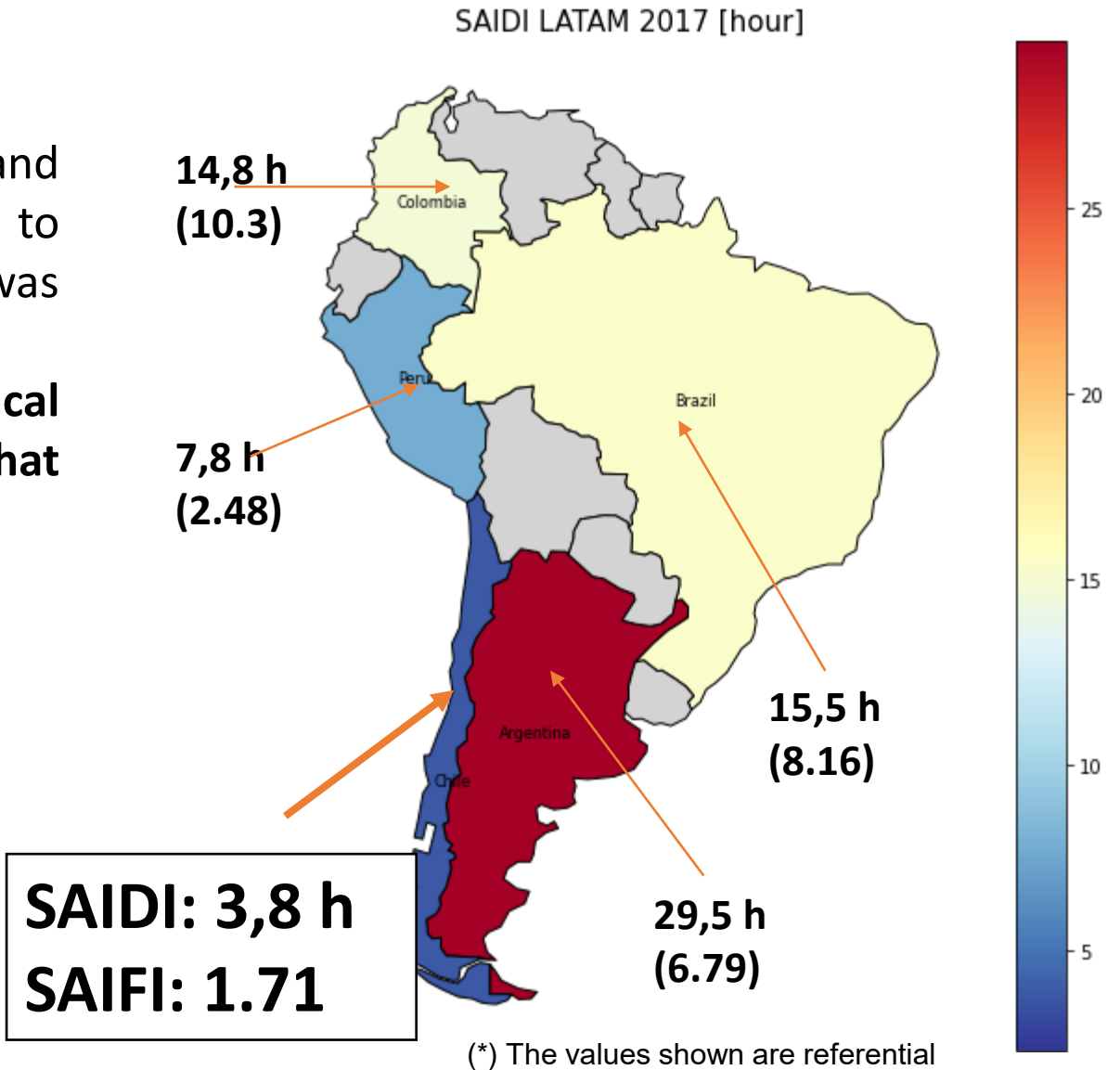


LATAM SAIDI (2017)

Problem

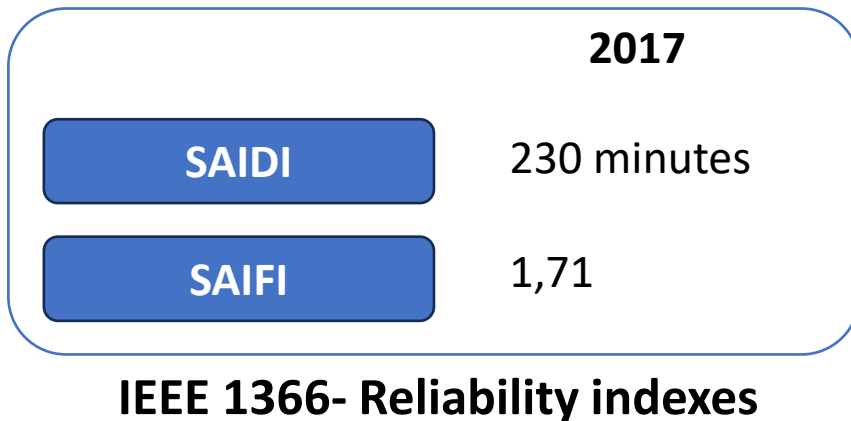
- Until 2017, a local indicator of frequency and duration in proportion to power was used to measure service quality (e.g. TTIK-FMIK) . There was no customer focus.
- **In 2017 the regulator establishes the new technical distribution standard due to snow event that includes the measurement of SAIDI, SAIFI**

The strategy of the enel group was to have a single quality indicator, and a strategy to improve it



Improving Reliability - Indexes

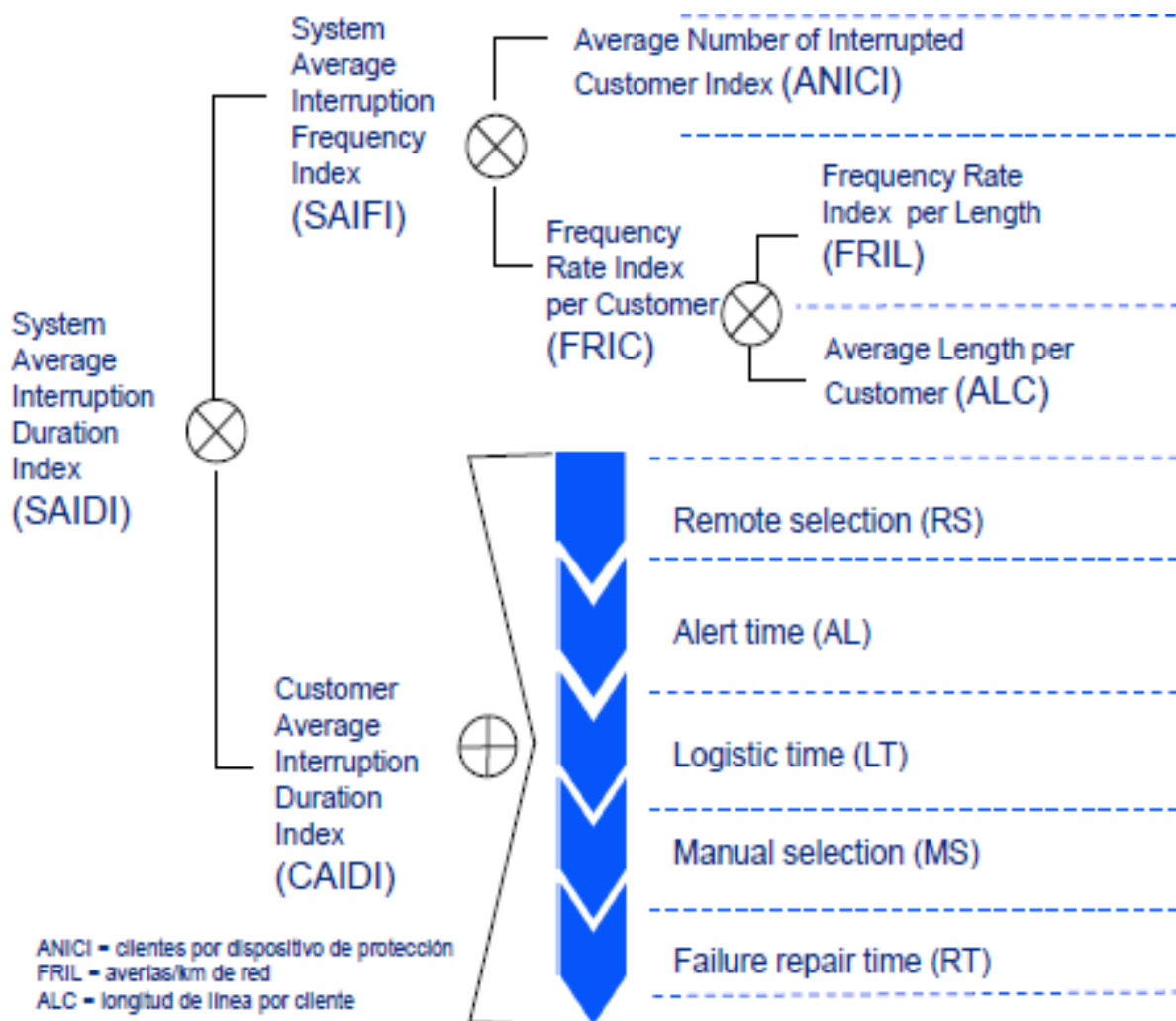
To improve reliability, the first activity is to measure it through indicators



Improving performance, which included reliability as its main axis, required the improvement of different actions in the Company.

- Methodology
- Infraestructure
- Maintenance
- Efficiency Process
- Apps/Process/Organization
- Cultural Changes
- Other Perfomance indicators

Improving Reliability - Methodology



Remote Control Points
Automatic selection devices <3 min
Protection settings

Inspections
Tree Trimming, Maintenance
Line reinforcement

New MV Feeders
A part is not manageable

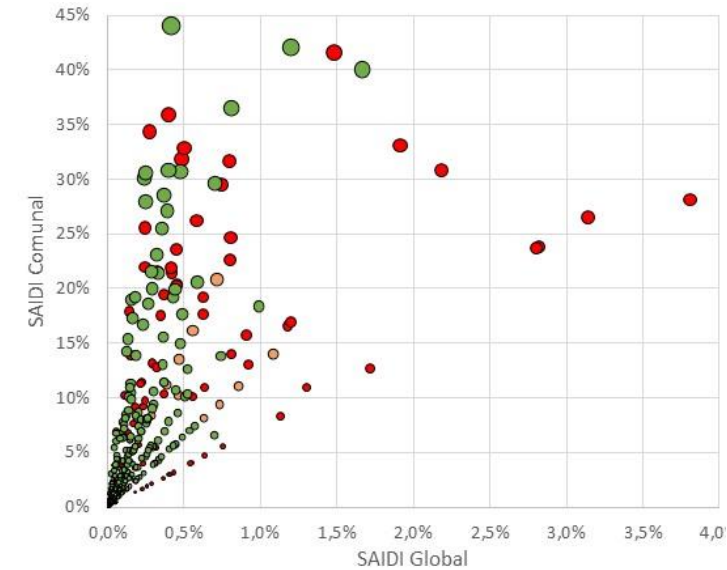
Remote Control Effects
Control center management

Field equipment alert
Contractor response time

Failure indicators
Optimization of routes and works

Procedures and work practices

Use emergency generation



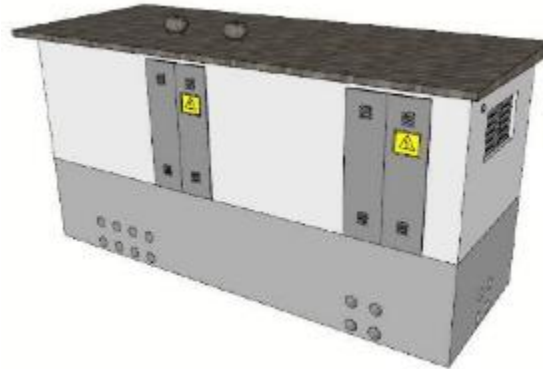
- Analysis is carried out by MV feeders and how much they weigh with respect to the total SAIDI of the company as well as the sector SAIDI.

Performing a decomposition of the SAIDI for each MV feeder, and determining sub-indicators, allowed us to carry out specific actions

Improving Reliability - technology incorporation



**MV Remote
Control Equipment**



**Switching Substation
MV/MV**



MV Automation



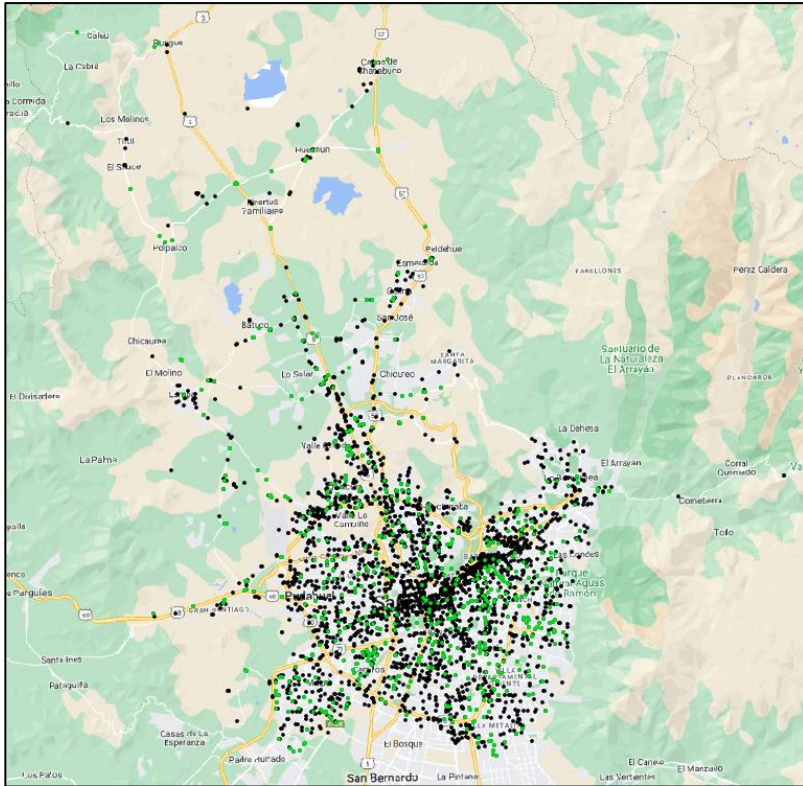
Smart Meter

- The incorporation of new technologies also required strengthening the existing medium voltage networks
- The remote operation of the electrical grid had a significant impact on the reduction of SAIDI

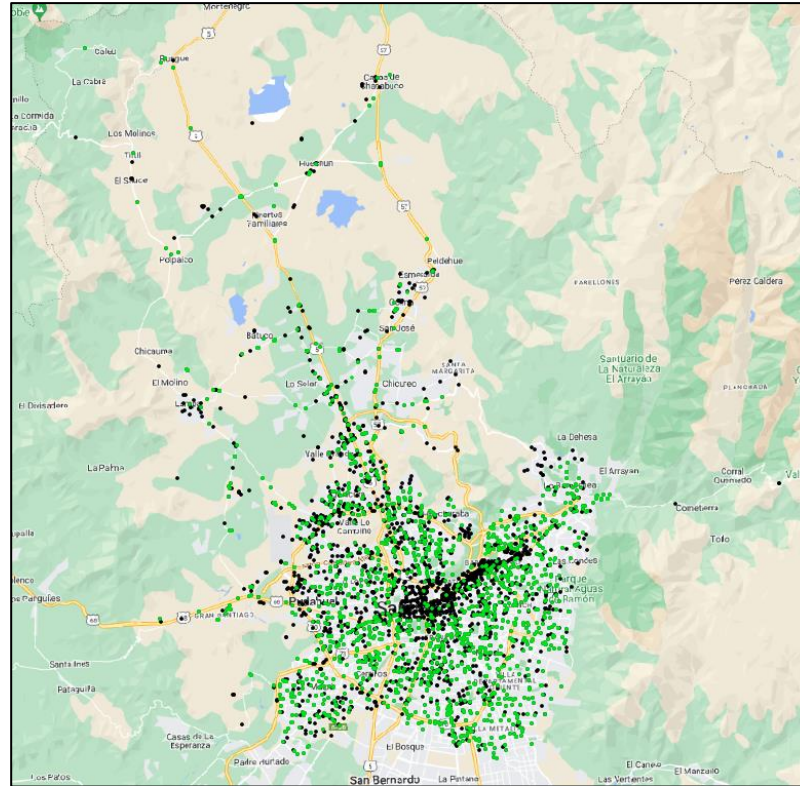
Improving Reliability – Remote Control Equipments

● Manual Switch

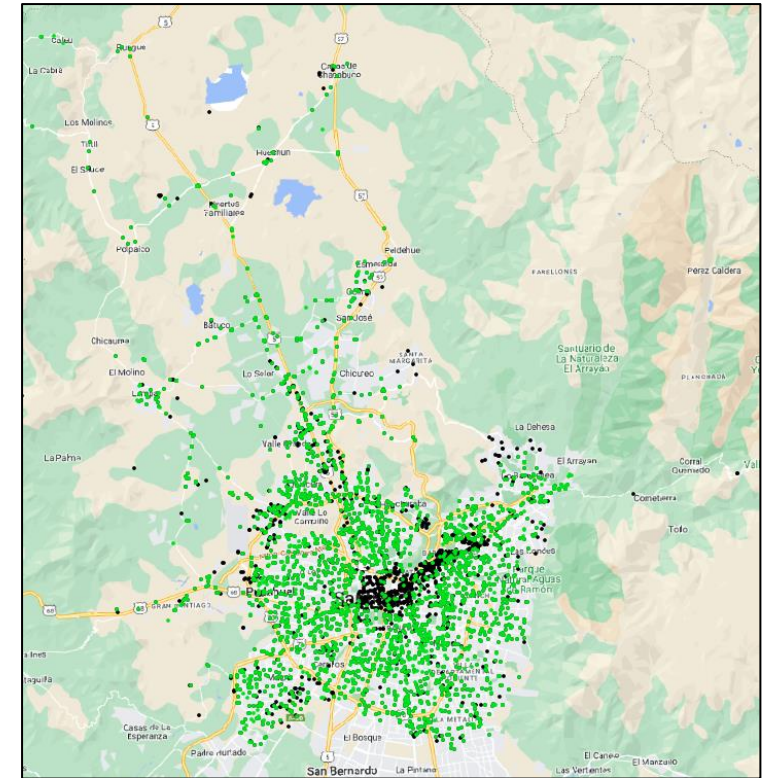
● Remote Control Switch



2016



2019

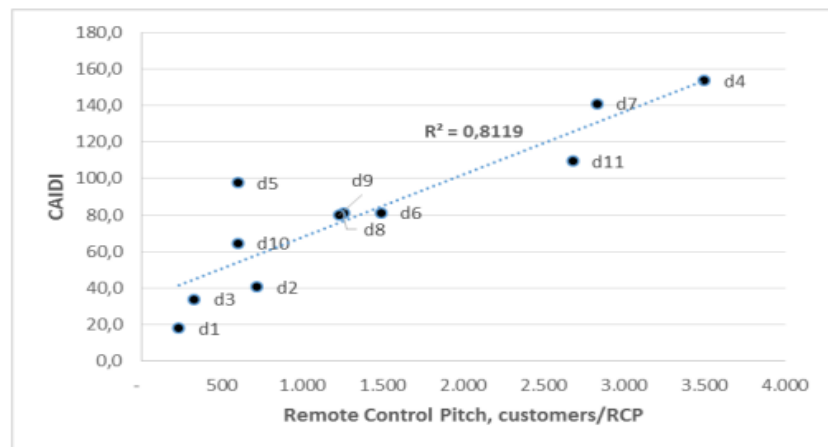
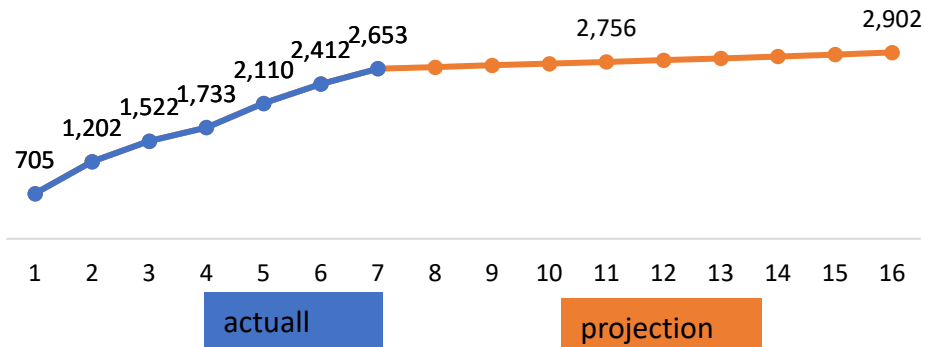


2023

In the central area of Santiago there are still many underground equipment to change

Improving Reliability – Remote Control Equipments

Remote Control Equipment



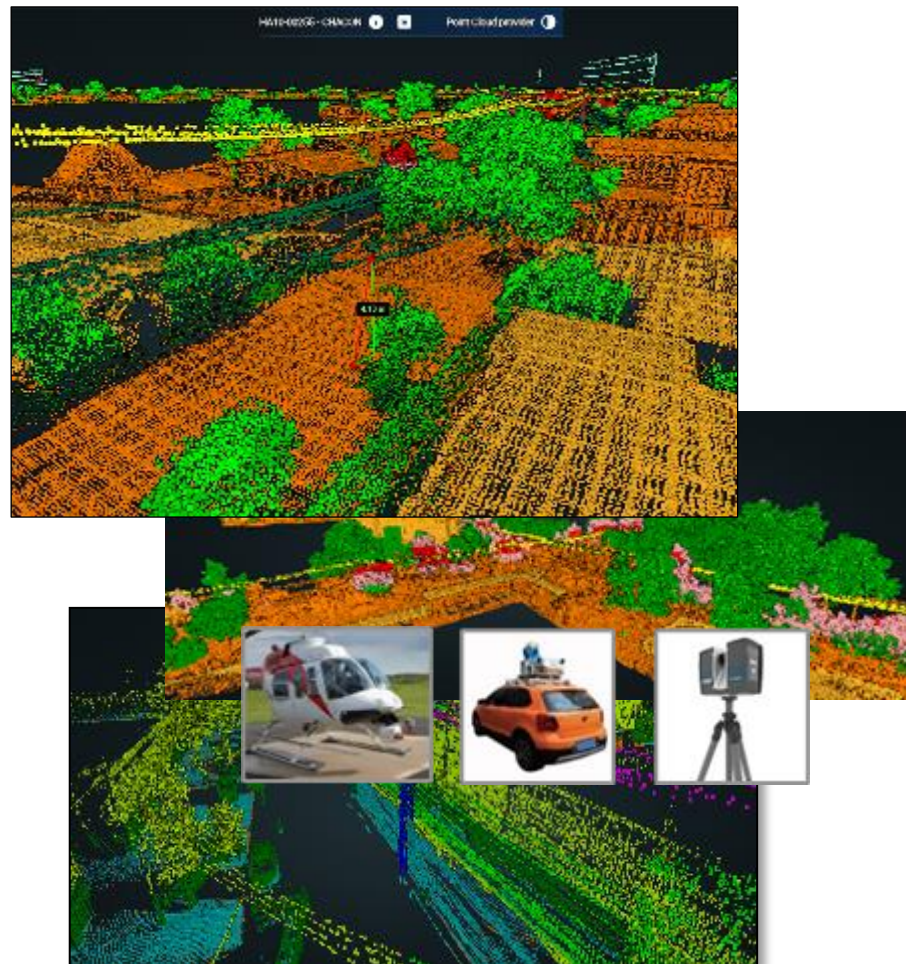
TELECONTROL

- 2,700 units installed
- Availability > 97%
- First Maneuver 7.8 min
- Successful Maneuver 82%
- Chile 2023: 750 customers per unit

The use of Remote Control Equipment has been fundamental for improving reliability, since although it does not prevent failure, it significantly reduces the impact

Improving Reliability – Maintenance

The Global Repository and 3D Modeling (GR&3DM) system was born as a solution to the need for digitization and modernization of networks. This consists of a global repository of information, an administrator (or brain) and a visualizer, allowing you to recreate a "digital twin" of the network.



Application

- Collects all the information obtained during inspections with helicopters, drones and mobile.
- It allows you to interact with the data processed and loaded in the preceding steps, navigate through the 3D LiDAR point clouds and the visualization of photographic records (integrated visualization)

Visualizer

- Distance Measurement Tools
- Viewing Photo Records Gallery
- Map navigation
- Colorization of the point cloud according to infrastructure and/or criticality

Benefit

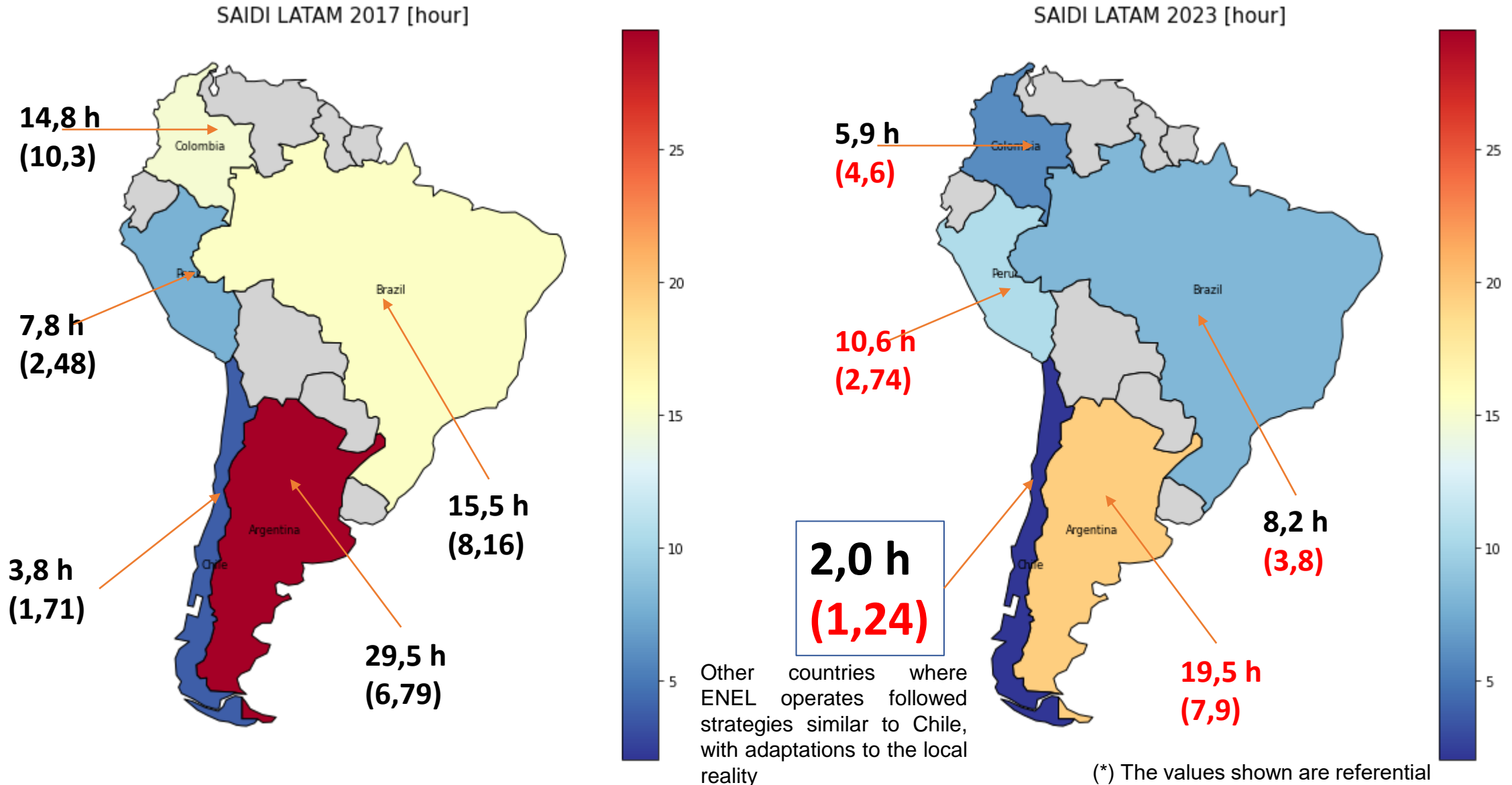
- Possibility of carrying out virtual inspections.
- Savings in time and costs for design activities, work plans, maintenance.
- Verify compliance with safety strips and distances, as well as the identification of structures outside the regulations.

Improving Reliability – Process Efficiency

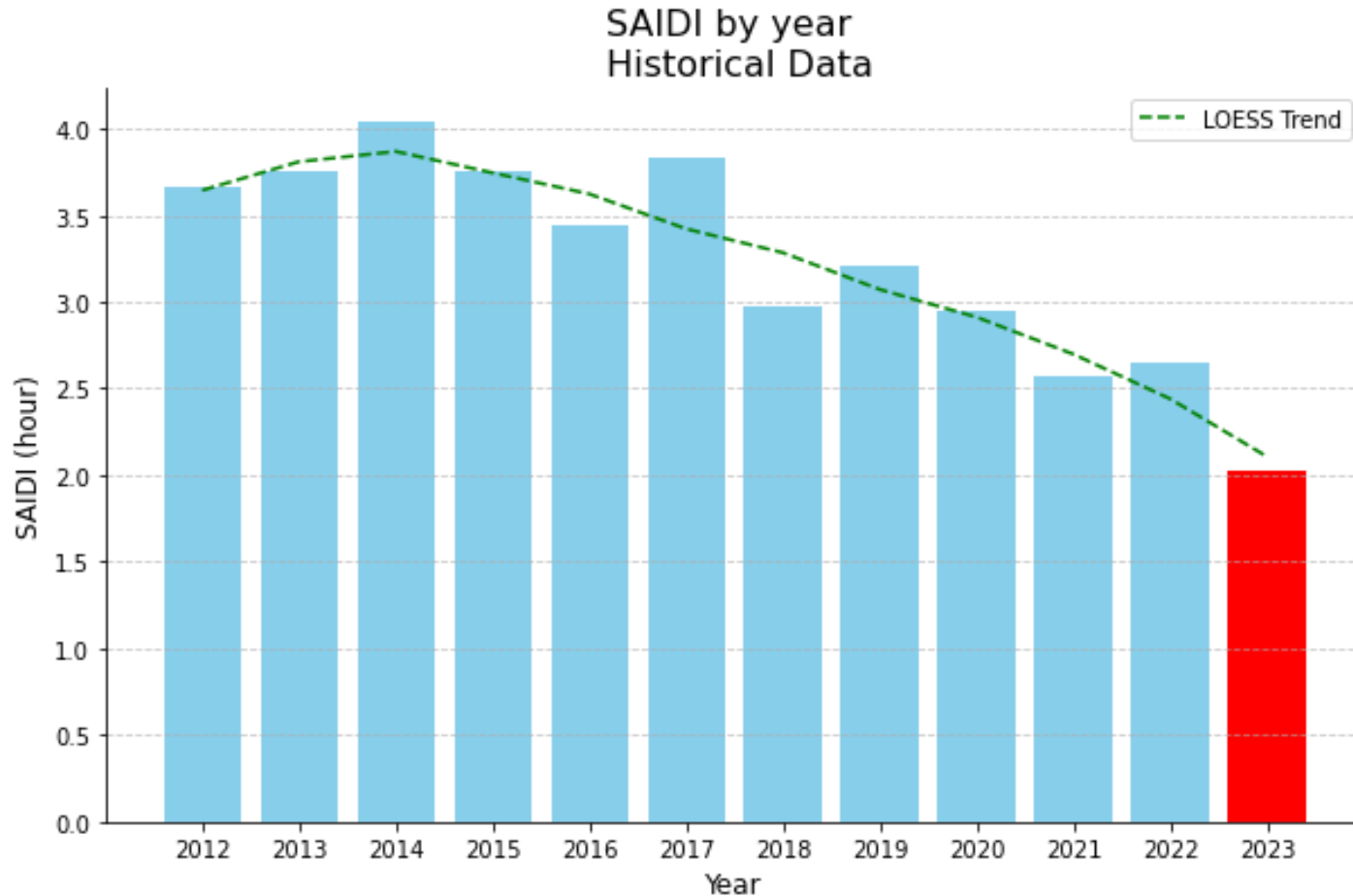


- Emergency Crew Shift Management
- Management Allocation of resources between zones.
- Complete CAIDI analysis (assignment time, transfer time and repair time)
- Location of resources in post of reduction of transfer times
- Use of corporate platforms for traceability of operations
- Monitoring of First remote control maneuver

Improving Reliability – Results



Improving Reliability – Results

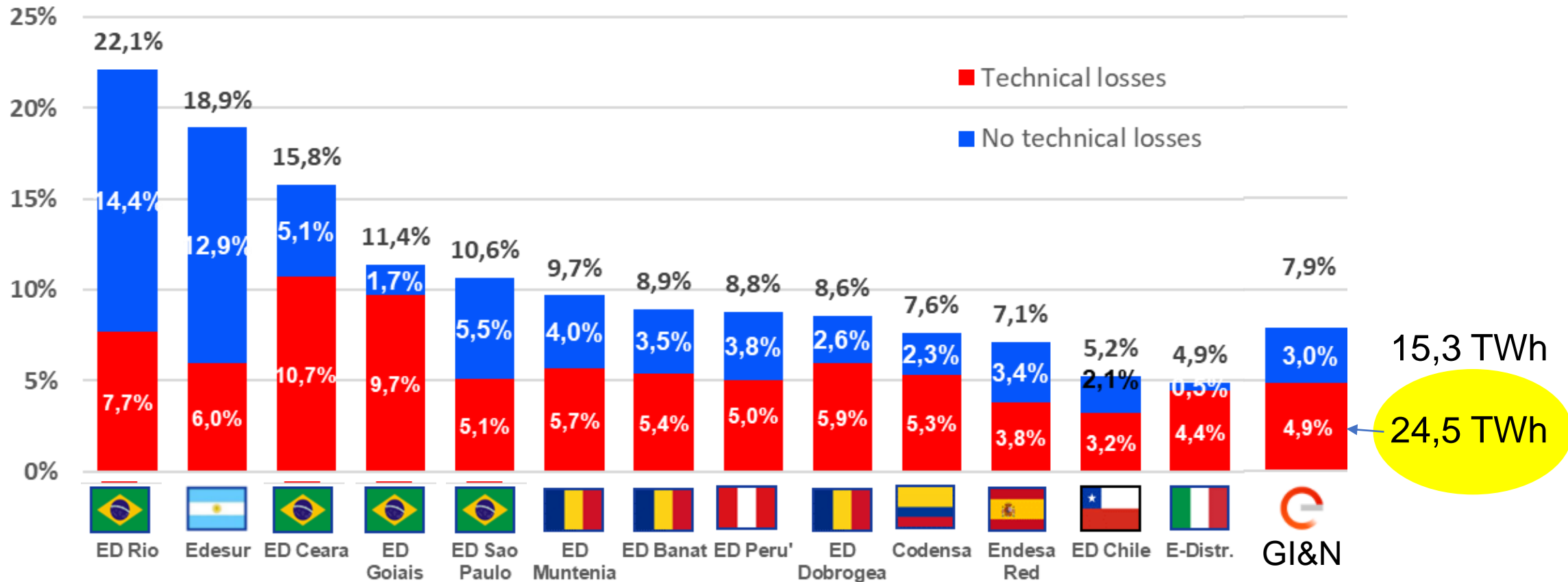


CHILE SAIDI EVOLUTION:

- Supply quality shows a clear trend of reduction in the long term, even though there are years where outcomes locally increase due to climatic or operational externalities.
- The remarkable aspect of the outcome is that the supply quality strategy must be supported by an infrastructure plan, adequate maintenance, and operational efficiency.
- Additionally, the importance of disaggregating SAIDI by CAIDI and analyzing the latter cannot be overstated, as it is essential for harmonizing investments with operational management to enhance overall service quality.

Improving Reliability – Other performance indexes

The losses index is another important performance indicator that is measured and managed by the Distribution Company.



(*) The values shown are referential

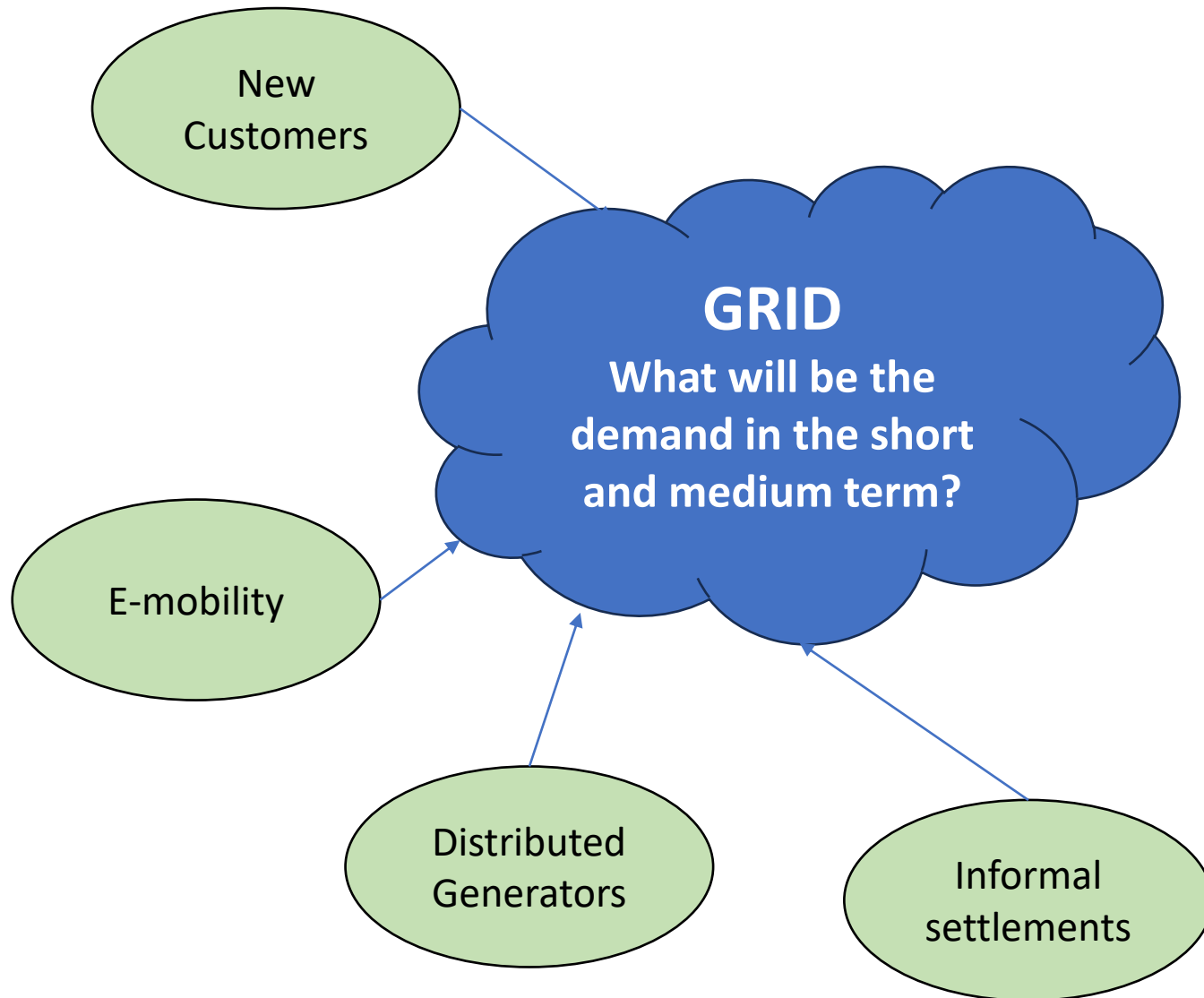
Improving Reliability – keys to success

- Define a strategy integrated into the processes and structure and known by all workers
- Monitor, analyze, take action and monitor again
- The digitalization process is continuous, as new technologies emerge.

Customers connection, Distributed generation and e-mobility



Customers, Distributed generation and e-mobility



The continuous increase in hydrocarbon prices has had a detrimental impact on energy customers' bills. However, a significant decline in renewable technology prices has created new opportunities for the generation sector and offers customers the chance to self-supply and reduce their energy expenses.

How the Distributor company can take advantage of this opportunity?

- New Technology must be consider
- Traditional analysis tools must be adapted
- Exogenous variables should be considered

Customers– Forecasting



In 2013, the Chilean government, under the purview of the Ministry of Transportation and Telecommunications, initiated the Santiago Public Transportation Plan, which aimed at the development of:

- ❖ Train services
- ❖ E-buses
- ❖ Cycling paths
- ❖ Subway infrastructure
- ❖ Cableway systems
- ❖ Concessioned roads

The 2025 Transportation Master Plan encompasses an integrated network that contemplates the construction of new subway lines, trains, bus corridors, concessioned urban highways, cable cars, and other road projects. These initiatives entail a total investment of nearly 22.5 billion dollars.

Cableway



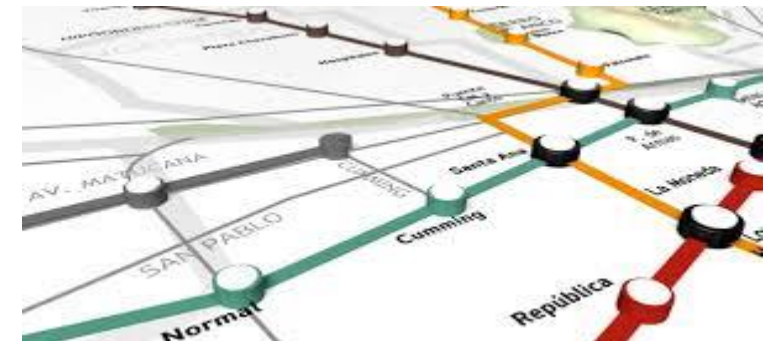
The construction of the new cable car will necessitate the relocation of high-tension power lines, as well as the power supply.

Train



The construction of two new train lines is envisaged: Santiago-Melipilla (22 km) and Santiago-Batuco (27 km). These projects will require significant undertakings for the relocation of medium-tension (MT) networks and electrical supply.

Subway



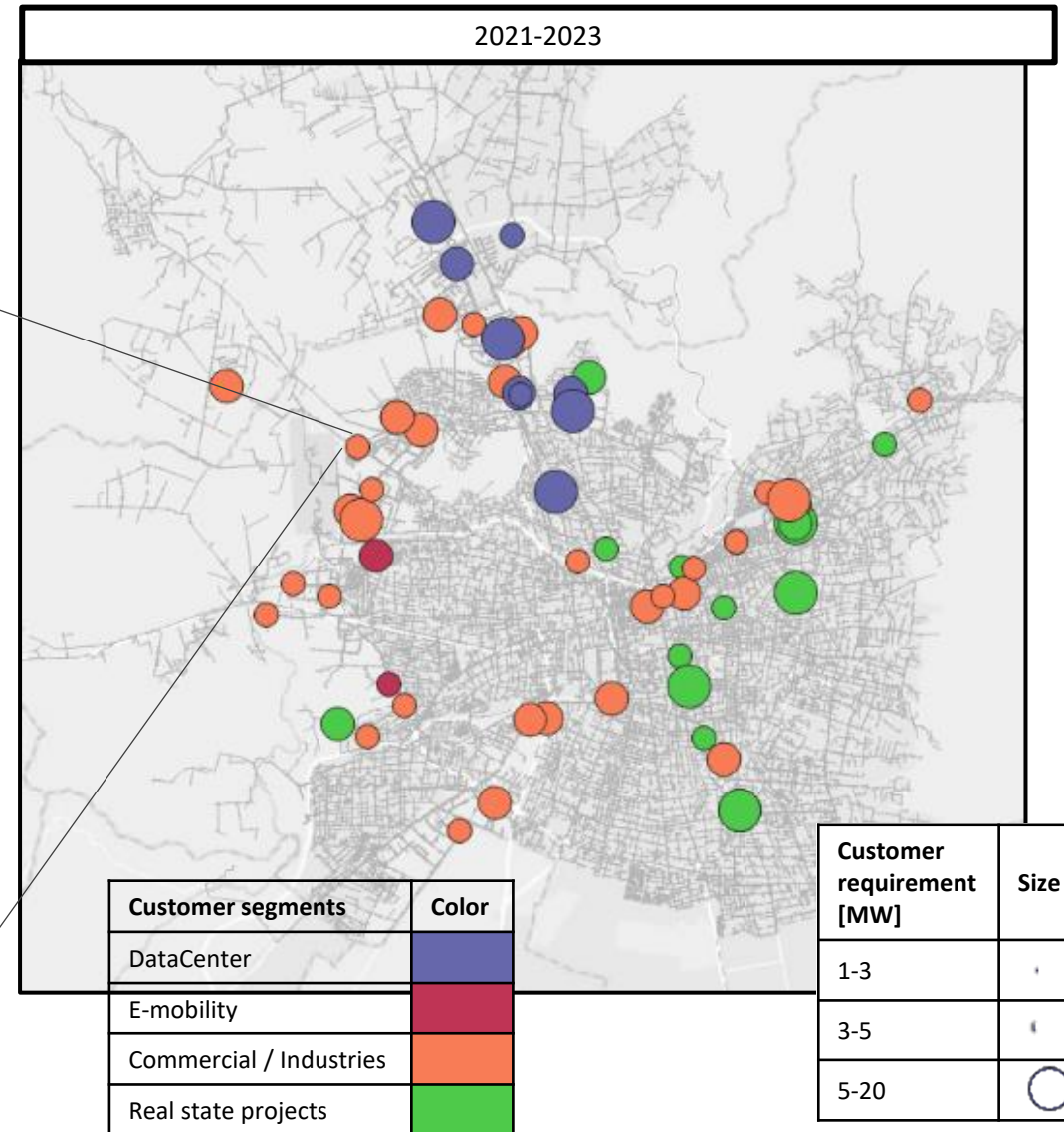
The upcoming Metro Line 7, with an estimated length of around 25 kilometers, is set for construction. Furthermore, expansion initiatives for Lines 6 and 3 are in construction stage.

In August 2020, Metro made a request to ENEL for a 6 MW power supply for the construction site.

Customers– Forecasting

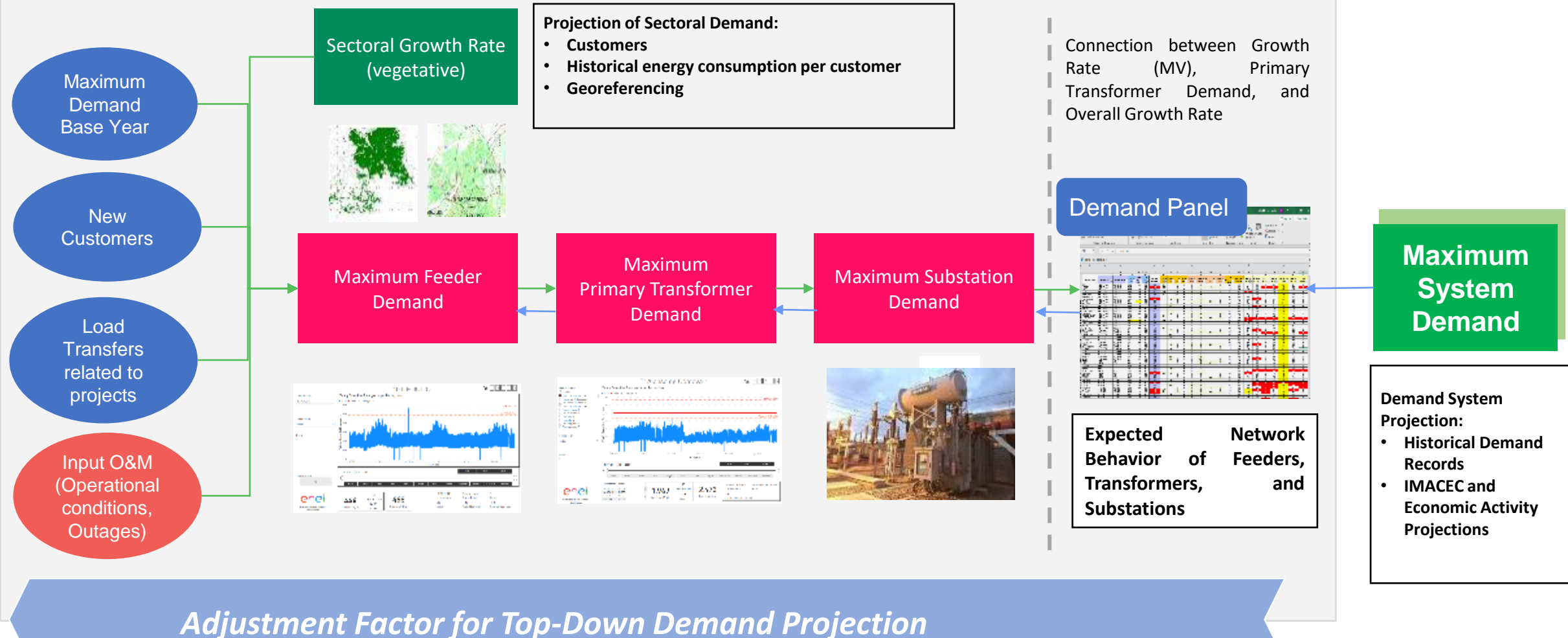


It is necessary to have digitized information from the electrical network and customer requests to carry out the analysis



Customers- Forecast

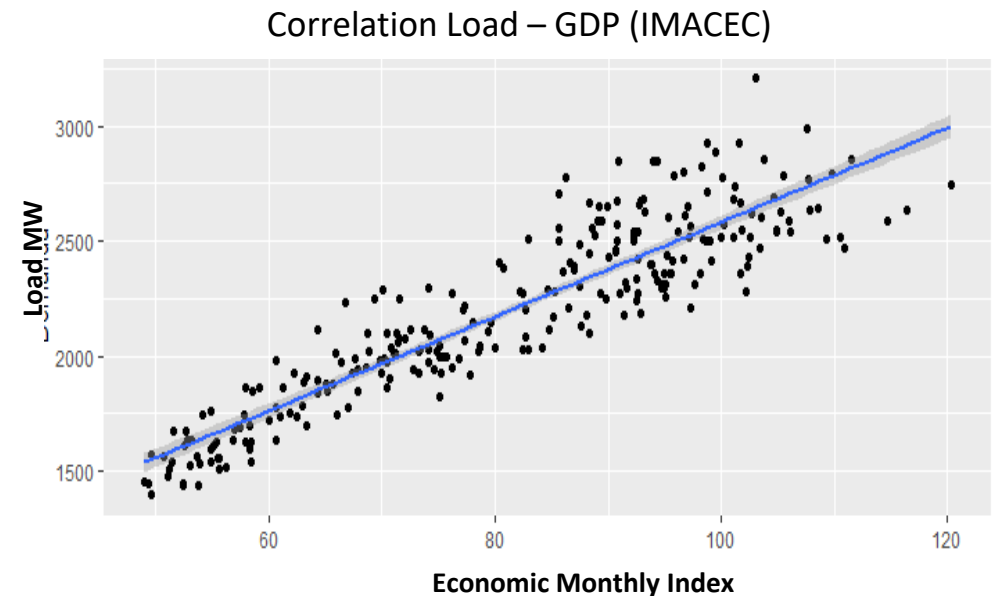
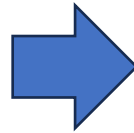
Bottom-Up Demand Analysis



Customers– Forecasting

The demand projection is carried out with time series models such as SARIMA (Seasonal Autoregressive Integrated Moving Average), which additionally includes indicators of economic activity, which in turn is projected through estimates of GDP growth, given the relationship direct from the latter with the IMACEC (Local Economic indicator).

Year	%GDP
2021	2.5%
2022	2,6%
2023	2.7%
2024	2.8%
2025	2.8%
2026	2.9%

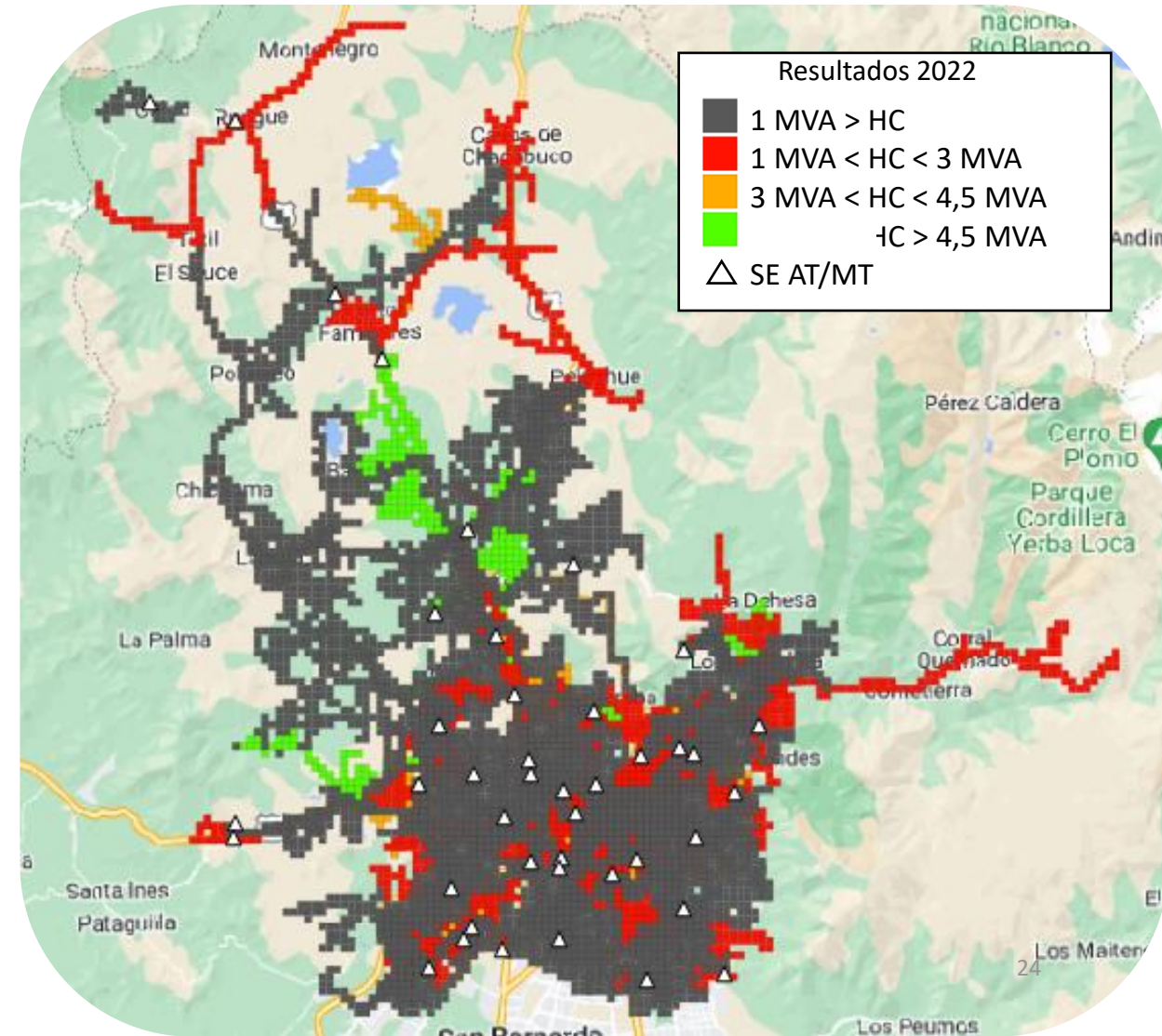


This model gives us a trend in the magnitude of aggregate demand, but does not allow us to determine growth by area

Customers– Analysis

Hosting Capacity

- HC is determined in areas of 500 m² on the MV network.
- HC has an MT look subject to the availability of power in AT/MT Transformation.
- As a result of the high demands registered in 2022, a significant limitation was observed in the HC to supply new customers



Small-Scale Distributed generation

- Energy Injection up to 9 [MW].
- By law, developers have guaranteed access to the distribution grid to their projects .
- To promote their connection, the regulator has established a stabilized price to valorize their energy generation. Therefore, they don't face the fluctuation of the spot market.

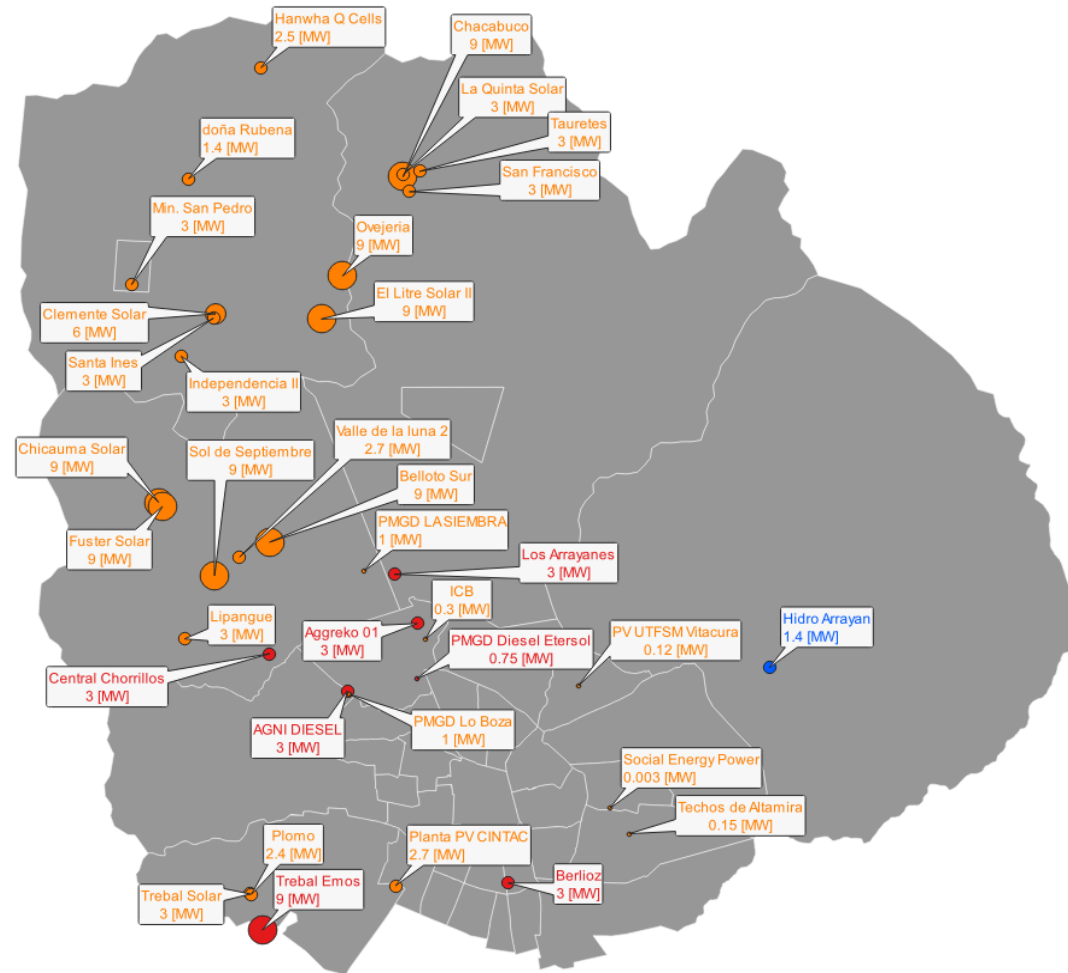


- Energy Injection up to 300 [kW].
- By law, customers can connect their generator systems in order to promote self-supply and reduce their energy bills.

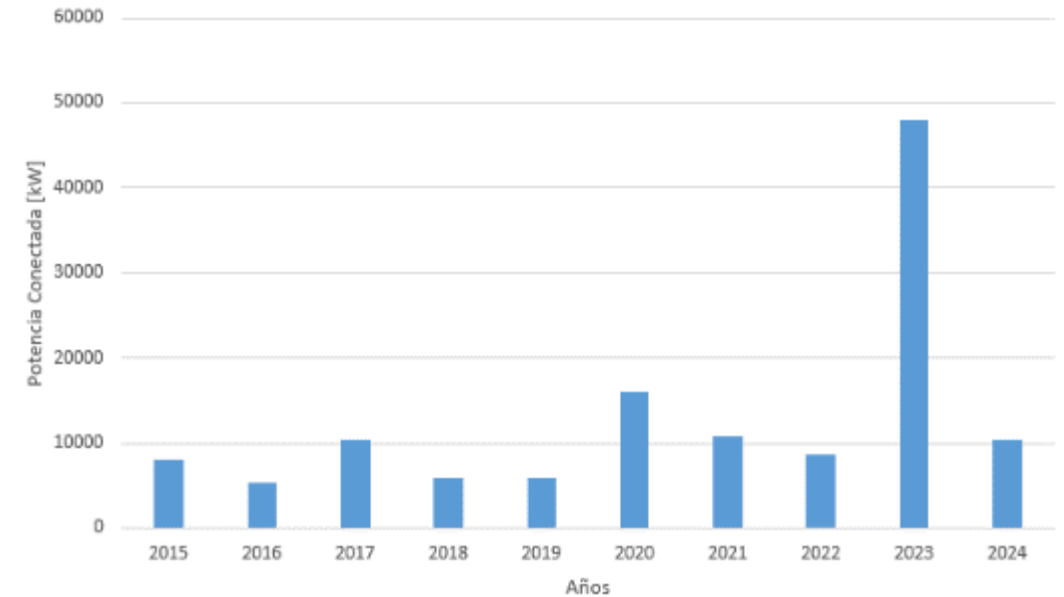
Domestic Generation

Small-Scaled distributed Generation

Evolution in Enel Distribución



Evolution of the conected power kw

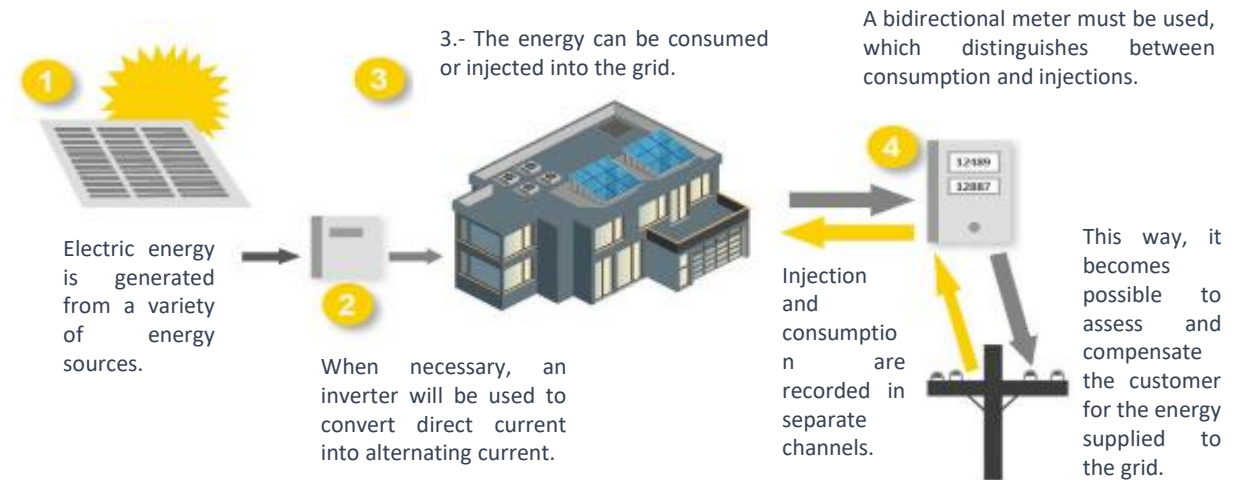


- Currently, distributed generation has surpassed the capacity of the distribution network in areas with high photovoltaic potential.
- In some cases the connection of generators has reduced the flexibility of the network
- The drop in storage costs will promote the utilization of the nighttime capacity of the distribution network, leading to an expansion of the time spectrum for technical studies.

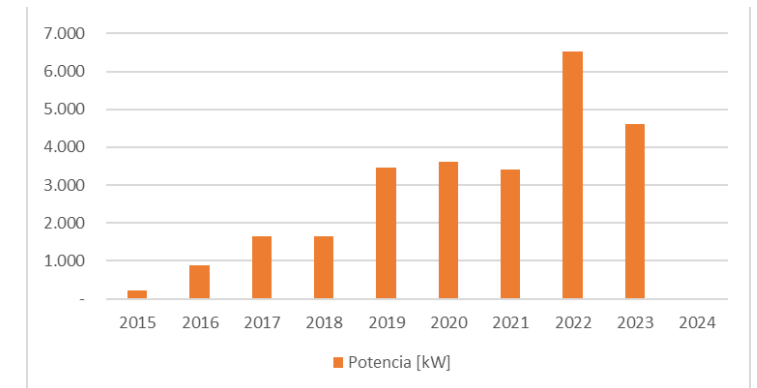
Domestic Generation

Project Develop, challenges and opportunities

- The energy injection from residential generators is compensated at a lower rate compared to small-scale generators. This is designed to encourage self-consumption over the injection of surplus energy.
- Consequently, projects that impact the grid are uncommon, as the required investment surpasses the compensation received. Generation is often restricted to prevent adverse impacts.
- A highly positive aspect is that this type of project promotes the transition from traditional meters to smart devices, an update that faced significant resistance from the public.



Power connected kW



Customers– Electric Buses

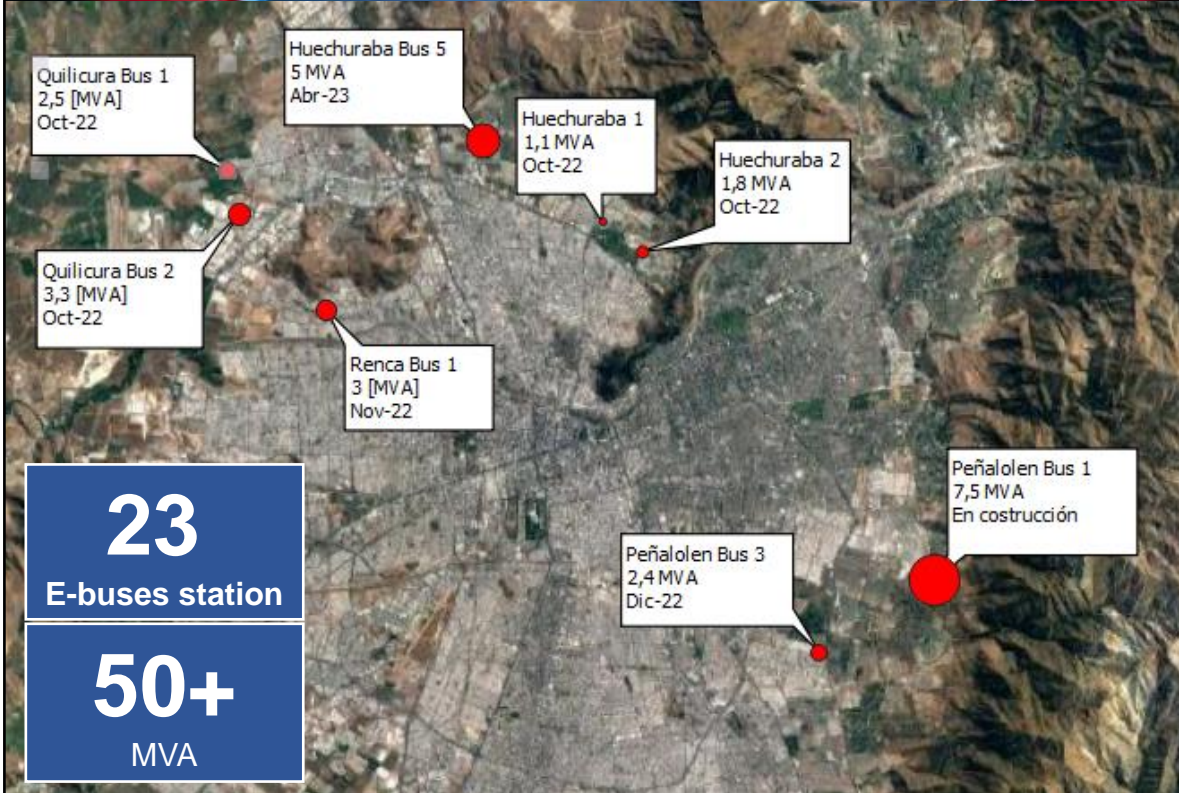
Features

- Low penetration of private electric vehicles
- Government strategy to make new buses electric through incentives (tender)
- There are no requirements for efficient bus loading.
- The adaptation of the electrical network is normally taking longer than the construction of bus stations.

Strategy

- New electrical studies using hourly curves
- Advice to clients through ENEL X about smart chargers
- Change of network switches that have the ability to disconnect the customers depending on the schedule (currently switches with fixed maximum current opening are used)

Customers- Electric Buses

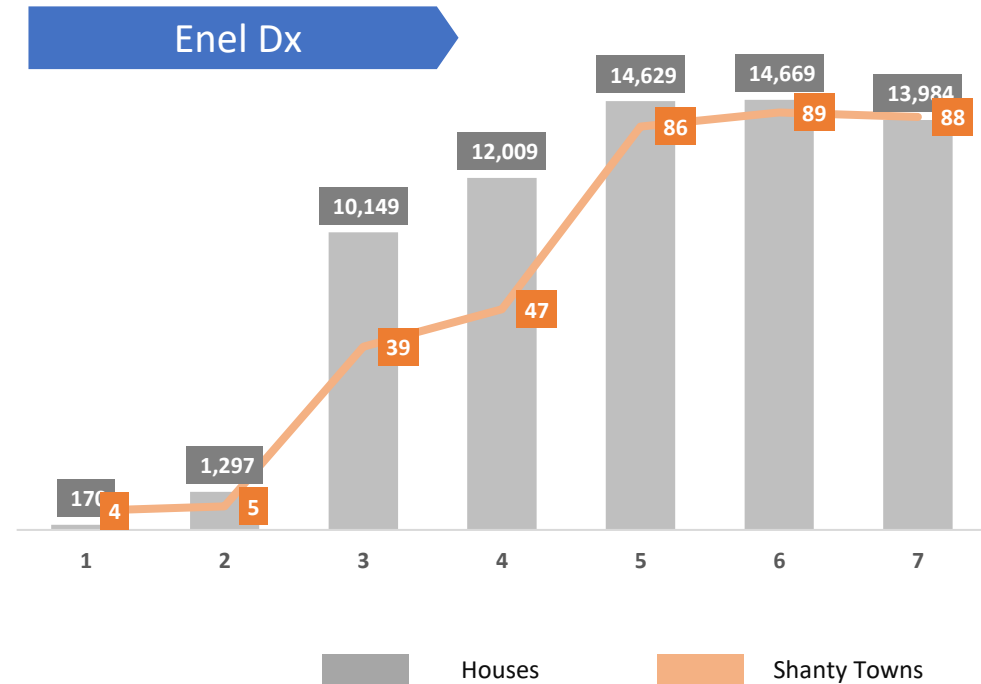


Today, the Chilean capital one of the city with the most electric buses outside of China. This is thanks to its fleet exceeding 2,400 zero-emission, high-standard units equipped with air conditioning, security cameras, Wi-Fi, USB chargers, and universal accessibility. *DTPM- Ministerio de transporte 16/01/24.*



Due to the charging behavior of electric vehicles, Enel is conducting hourly analyses to assess the impact on each customer. This enables us to enhance connection possibilities and operate our grid with greater flexibility.

Customers- Informal settlements



- In Chile, a problem of irregular clients has increased since 2020 due to : pandemic and immigration
- The information must be considered in demand forecasts.
- The solution, more than a technical one, is a joint work with the communities

Customers – Challenges

- Advance the integration of applications to allow to simulate the network with the different types of connected clients.
- Change from the passive model to a demand management model (e.g. network design, agreement with generation, etc)
- Prepare the electrical network for the electrification of customers and the energy transition.

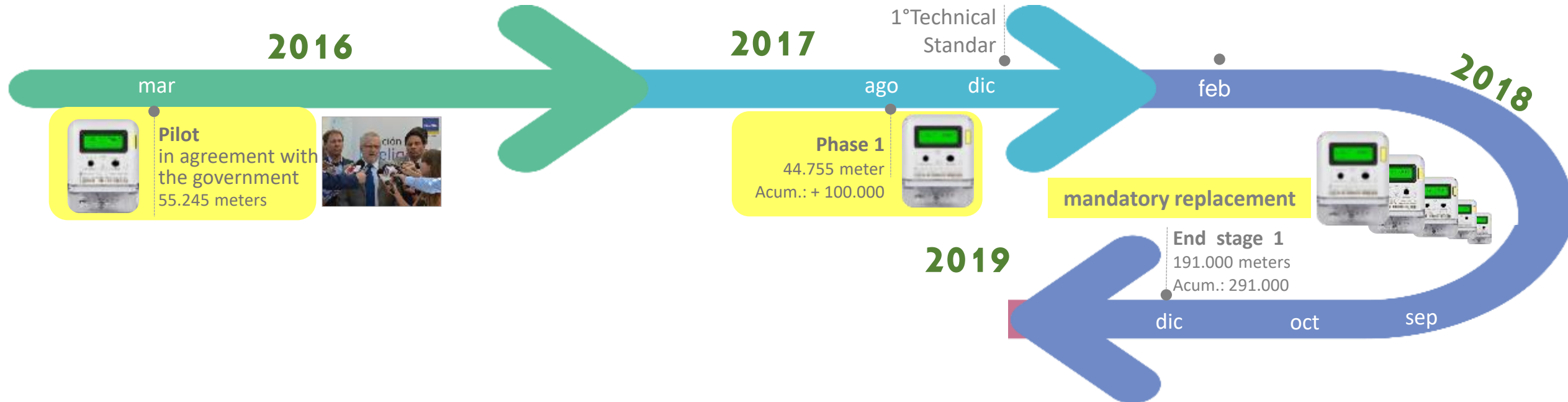
Smart Meters implementation

Problem:

During the smart meter implementation process, a communication problem was generated with customers. This caused the regulatory conditions to be changed and the project to be delayed

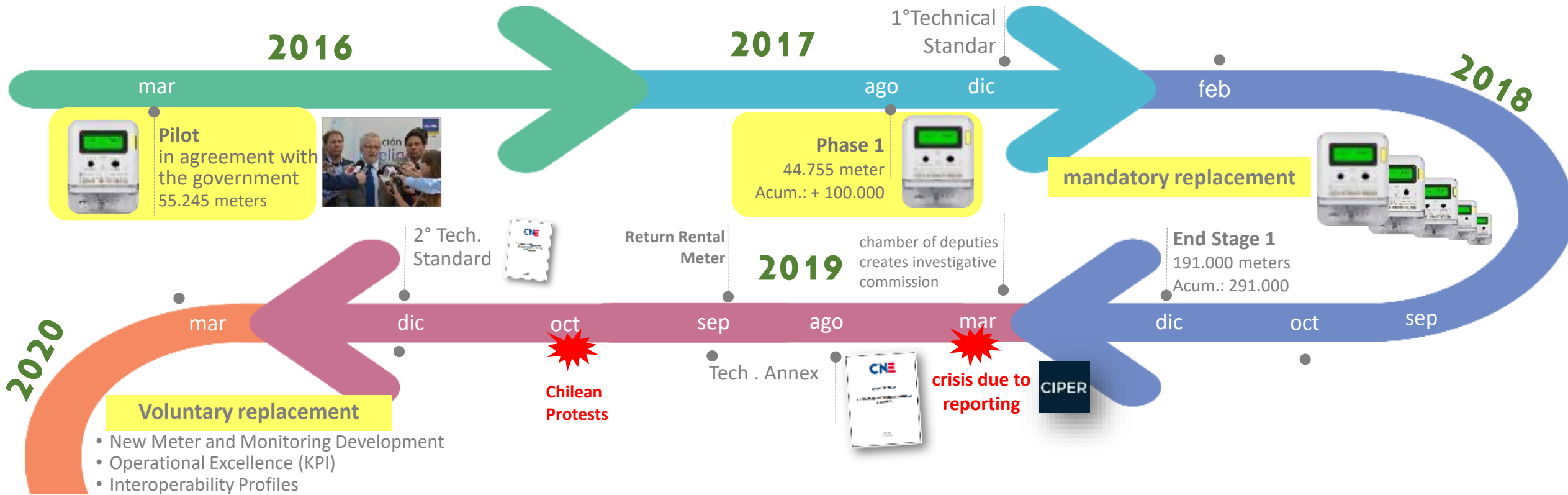


Smart M. Implementation - Timeline



- Based on the Smart Meter implementation experiences within the ENEL group, it was decided in 2016, together with the Government, to carry out a pilot project for the installation of Smart meter
- During the pilot project, 55,000 smart meters were installed
- The technology used was based on the Spain model called Cervantes
- Until 2019, the replacement was carried out on a mandatory basis and recognized in the tariff.

Smart M. Implementation - Timeline



A article from a local newspaper, protests and COVID produced important changes in the development of the project

Smart M. Implementation – Press Issue

- On March 2019 a report by CIPER revealed that a law with express processing forced distribution companies to change all meters with customers charging US\$ 1,000 million. The controversy escalated.
- Smart meters aroused distrust among customers, who refused to change, as they identified them as a business for companies that have large profits. Enel appeared in the media as the company with the highest profits in the sector, which had changed the most meters, devices that it bought from its own company and charged its customers

“... 86% of Chileans do not want to change meters...”



Devolución de cobro por medidores inteligentes será de \$1.000 promedio por cliente

Así lo confirmó el gerente general de Enel Chile, Paolo Pallotti. Agregó que la disminución se percibirá en septiembre.

“... Refund of the cost of smart meters will be 1000 on average per customer...”

“... Smart meters will be installed for an amount of 1000 MUS\$ that will be assumed by clients...”

- The government decrees that the change will be voluntary.
- Enel must return profit associated with the meters

CIPER ACTUALIDAD CIPER ACADÉMICO DEBATE TRANSPARENCIA RADAR

INVESTIGACIÓN

Instalarán nuevos “medidores inteligentes” de electricidad: el costo de US\$1.000 millones será asumido por clientes

18/03/2019

Por Gustavo Pérez

TEMAS: Construcción, Electricidad

Únete a la Comunidad CIPER

Únete Social

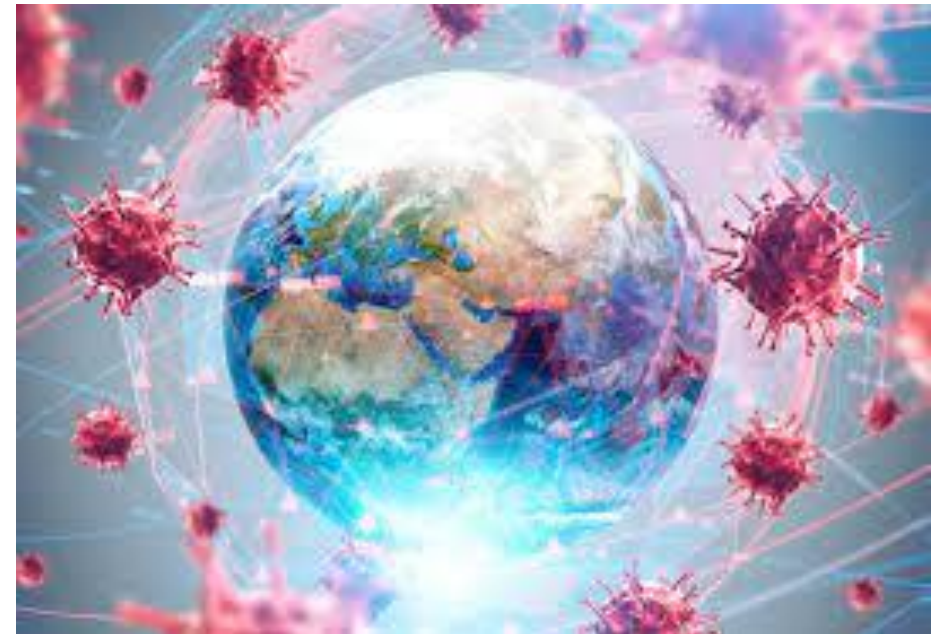
Se abre un nuevo espacio en la política por el reembolso

Enel y CGE discrepan de pago propuesto por Gobierno para clientes con medidores antiguos

Mientras la eléctrica acepta haber overinvestido para compensar a los clientes, CGE sugirió rebajar la implementación de los equipos inteligentes. Cooperativas se hacen acciones para el cambio. Cooperativas eléctricas afirman que

Smart M. Implementation – Social Crisis Chile

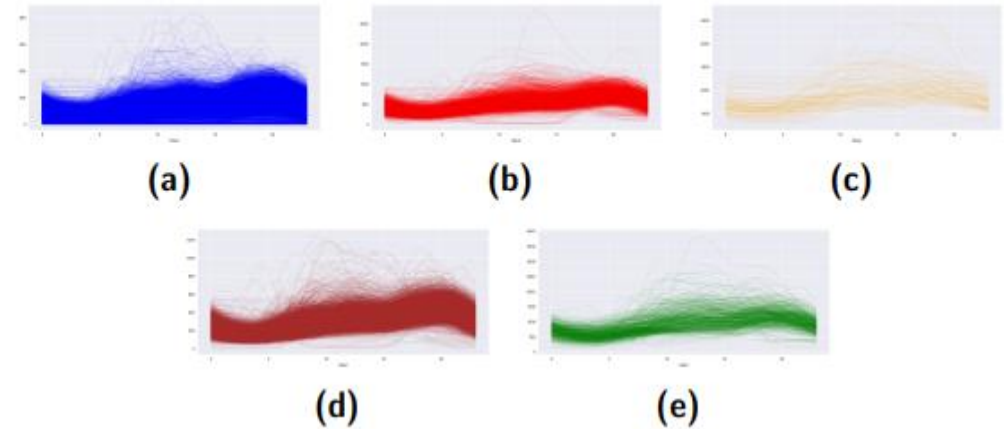
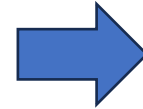
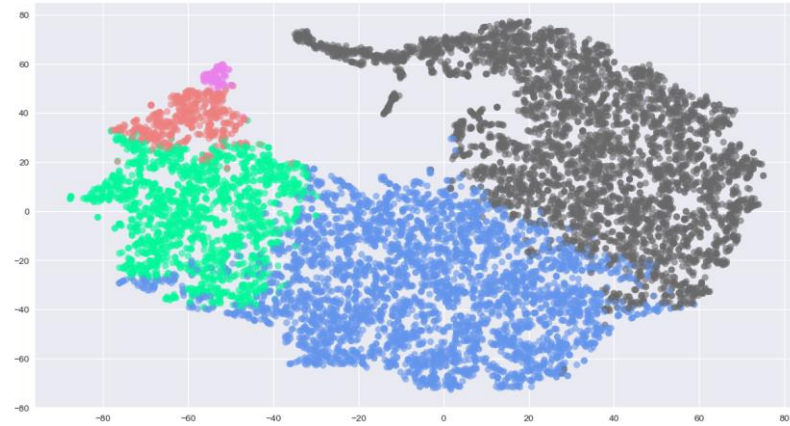
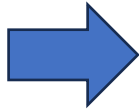
- In October 2019, the social crisis began and the change of meters emerged on the banners of those protesting against companies in general. In Dec 2019, was defined a specification not compatible with Cervantes meters
- At the end of the year it is established that it will be the customer who requests the meter change and the device will be installed only to those who expressly accept it, and the cost will be paid through a monthly lease by whoever has it.
- In 2020, the coronavirus pandemic interrupts the topic, the concerns and the media agenda change.



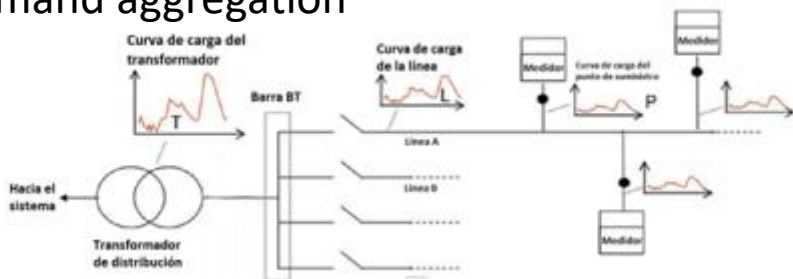
S. M. Implementation – Alarms

The data is used with unsupervised machine learning techniques and obtain different clusters of demand behavior

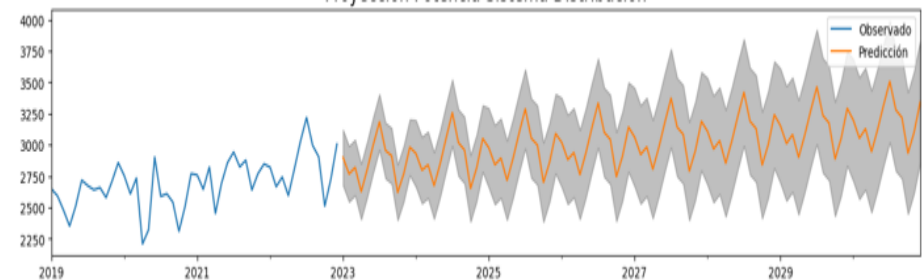
Smart Meters
Data



predict the overload level of a transformer using demand aggregation

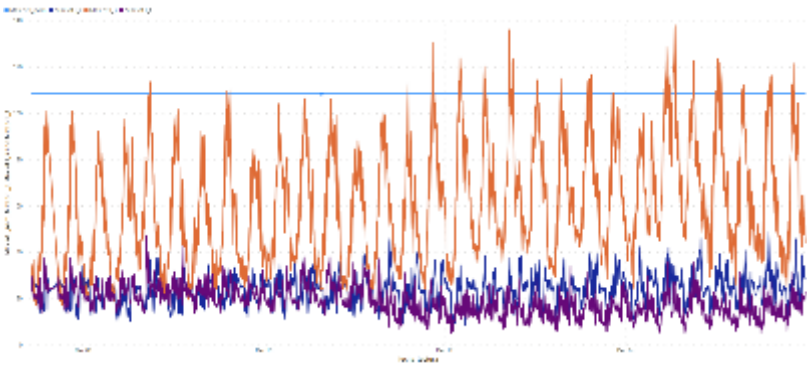


make future predictions using demand forecasting techniques

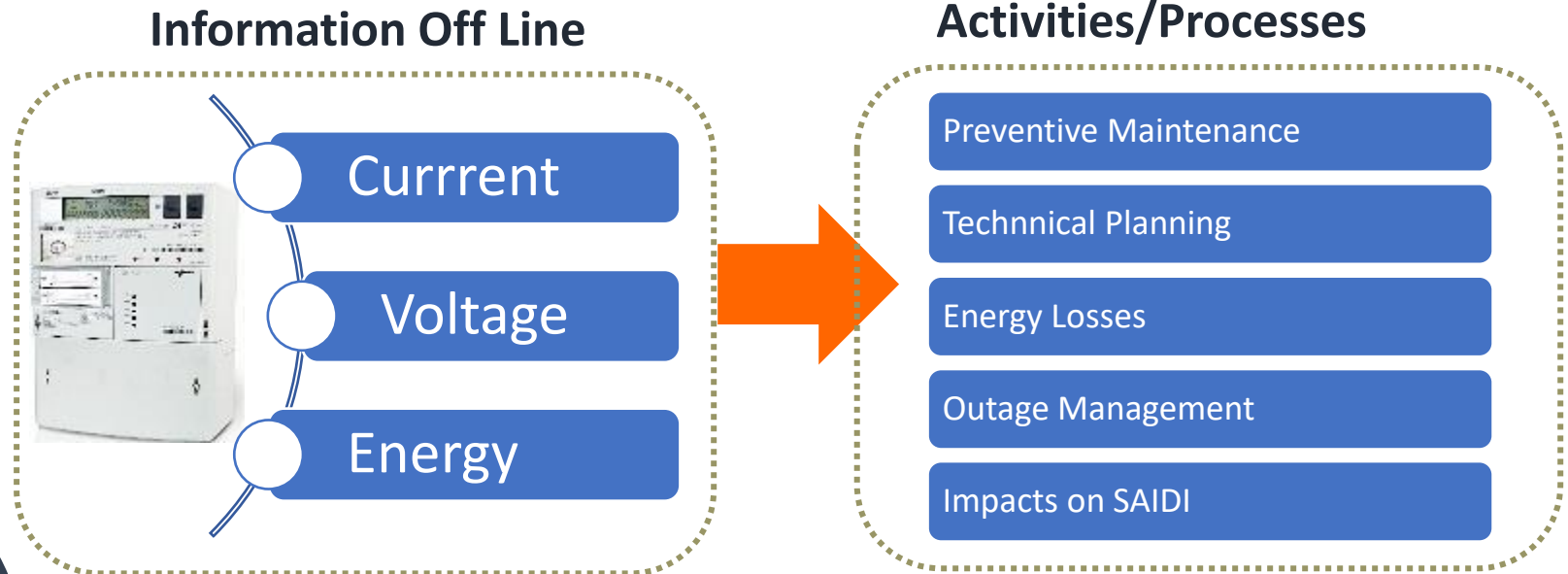
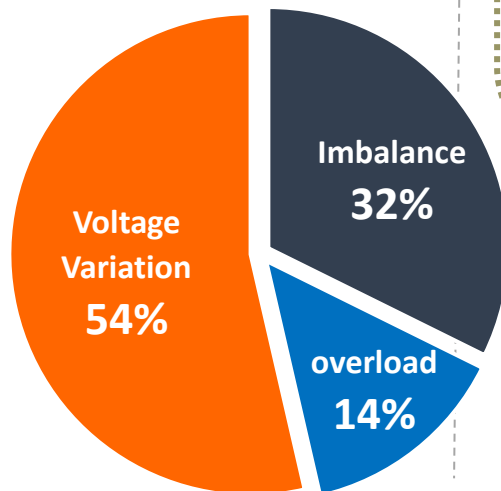


S. M. Implementation – Alarms

Since the project was stopped, smart meter teams developed alarm systems to detect problems in the network

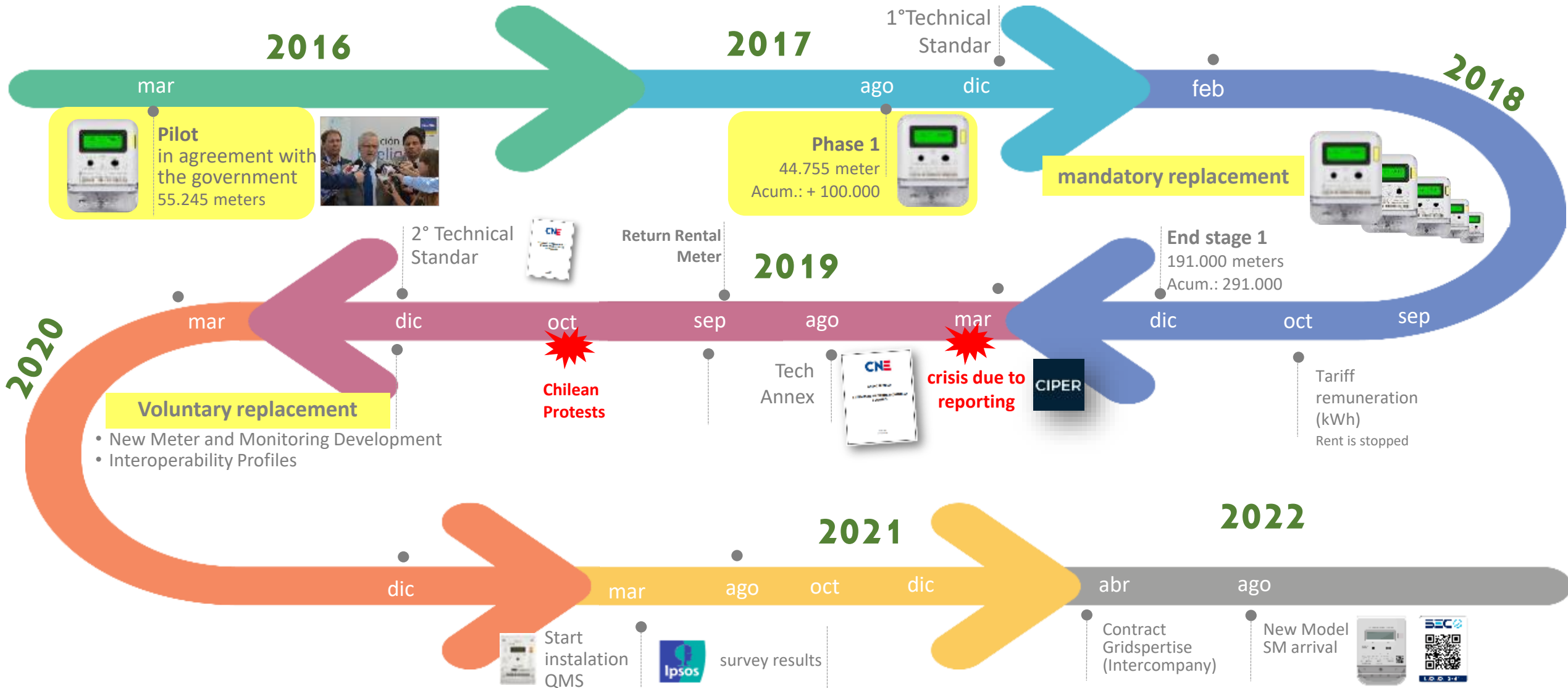


Alarms 2023
4,133
Transformers
1,468



The data recorded by the monitoring meters are used in different activities/processes.

Smart M. Implementation - Timeline

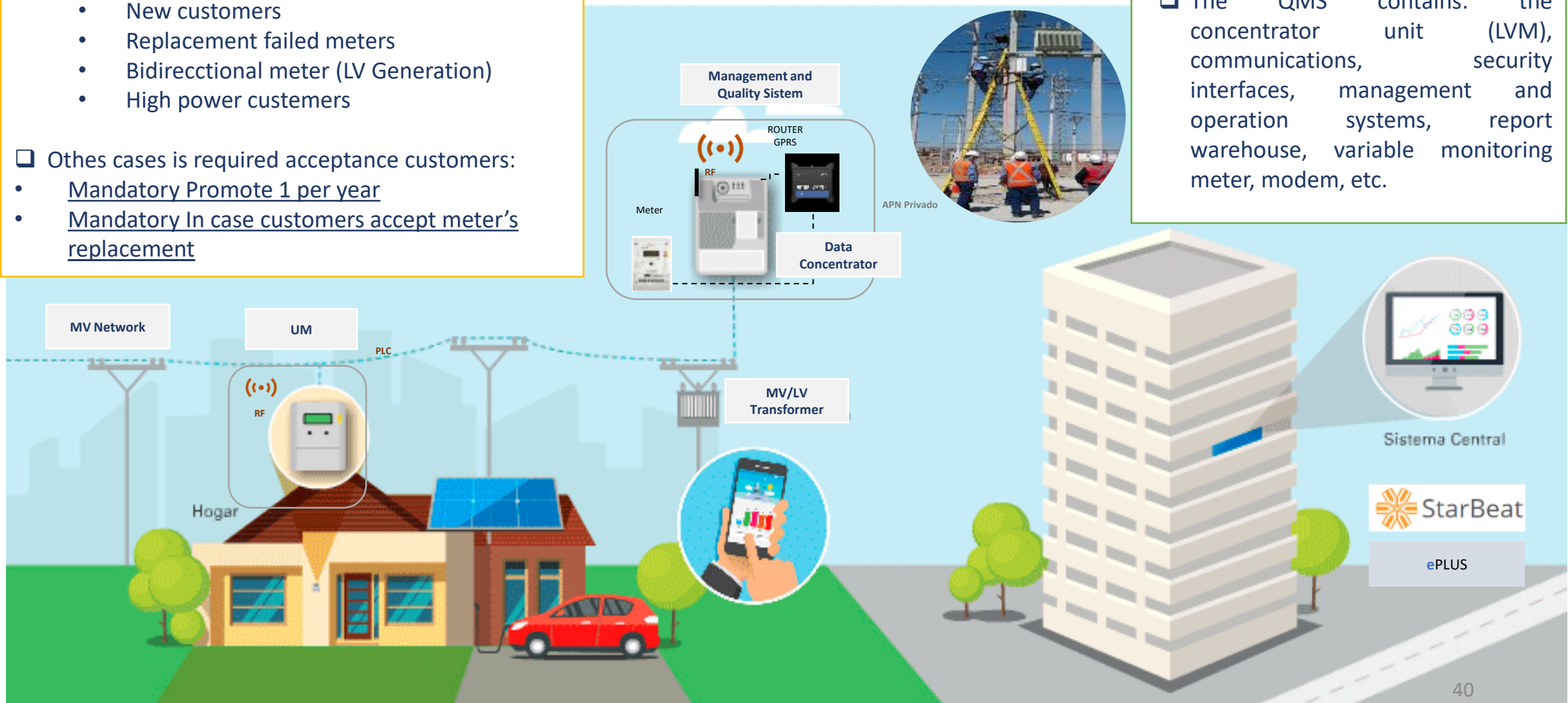


Smart M. Implementation – Enel Solution

SMART METER (UM)

- ❑ No customer acceptance required
 - New customers
 - Replacement failed meters
 - Bidirectional meter (LV Generation)
 - High power customers
- ❑ Other cases require customer acceptance:
 - Mandatory Promote 1 per year
 - Mandatory In case customers accept meter's replacement

- ❑ The QMS contains: the concentrator unit (LVM), communications, security interfaces, management and operation systems, report warehouse, variable monitoring meter, modem, etc.



S. M. Implementation – Customer Solution

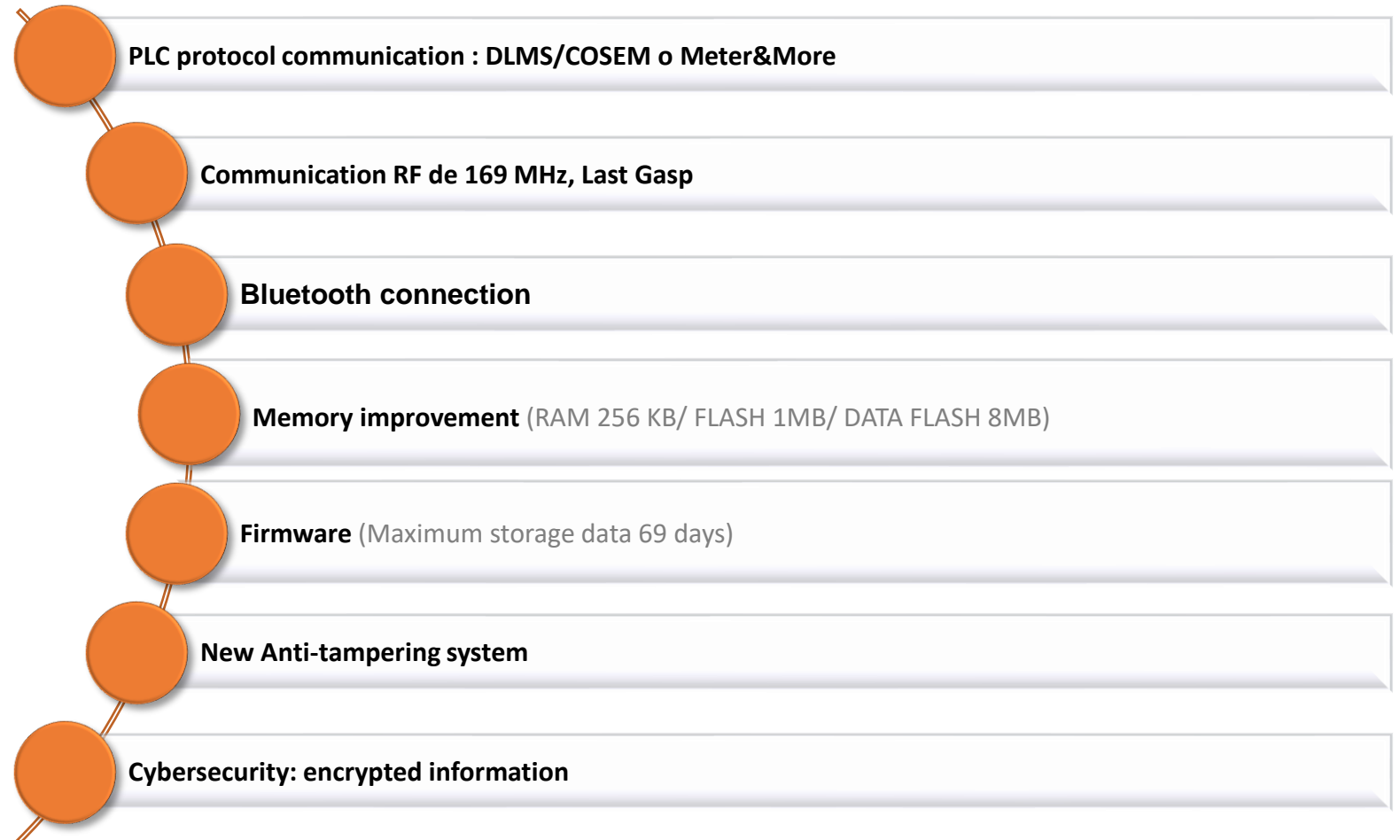
Cervantes1



NEXY-M

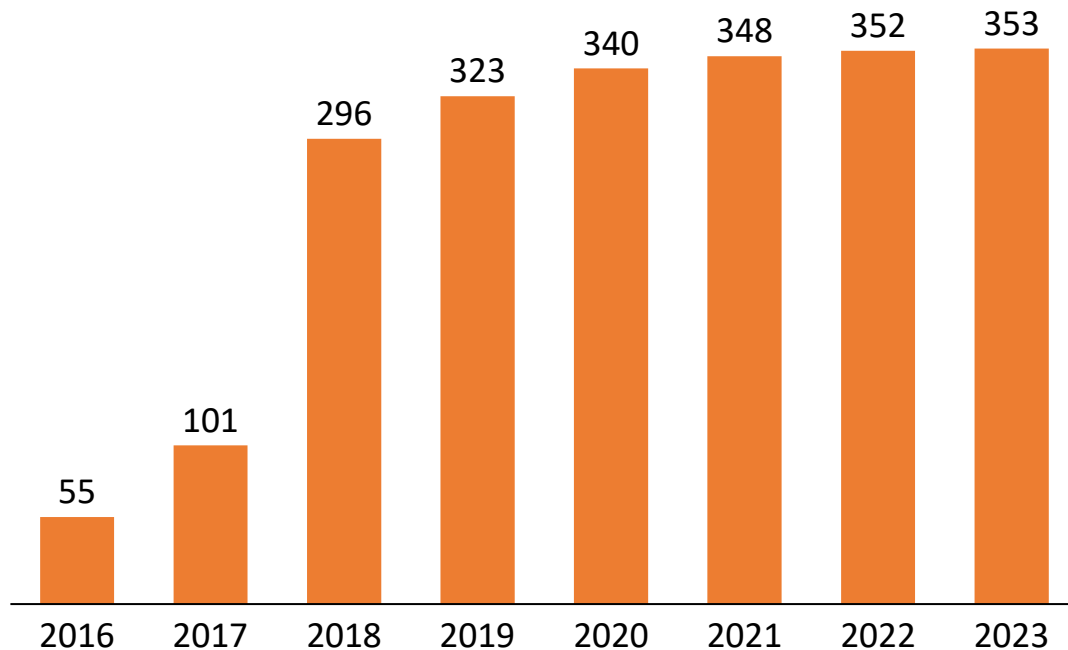


The experience gained allowed ENEL to improve both the quality and reliability of smart metering products.

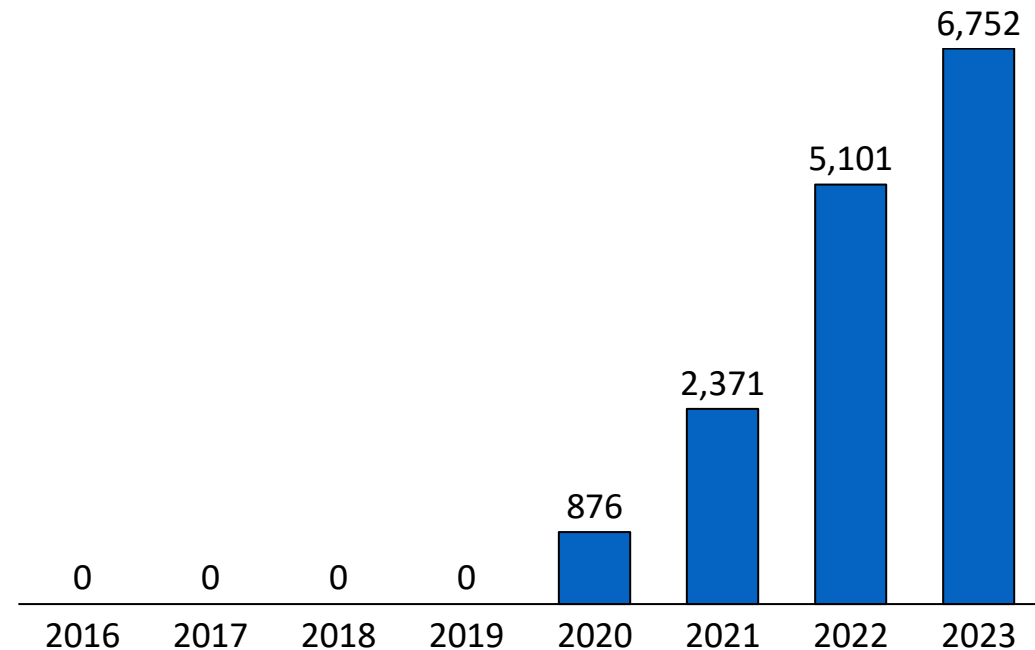


S. M. Implementation – Installation

To date there are 353k smart meters



To date there are 6,752 monitoring devices on MV/LV transformers (concentrator)



The installation of equipment on distribution transformers enables the possibility for customers to request the installation of smart meters. By 2025, there must be 100% of the metered transformers installed, that is, approximately 25,000

S. M. Implementation – Final Remarks

- Distribution Companies can work together with the Regulator to improve the service and incorporate technology.
- Customers perceive some benefits of smart meters. However, some features that involve higher costs are difficult to accept.
- Any modification that may affect clients must be correctly and timely communicated and in coordination with the Authority.
- The implementation processes have an adjustment phase, but that can be taken as an opportunity to improve the solution

Thank you !



“...We believe that by working together we can create a new energy era in which the world can become more sustainable...”

- Rodrigo Maldonado
rodrigo.maldonado@enel.com