

Concerning the Electrical Event on July 16th

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Secretaría de Gobierno de Energía
Ministerio de Hacienda
Presidencia de la Nación

1. General concept about the electrical systems
2. Situation previous to the event
3. Sequence of the event
4. Causes
5. Taking action to recover the system
6. Responsibilities in order of sequence
7. Preventive and corrective actions
8. Process for determining penalties
9. Comparative performance of SADI over time versus other countries

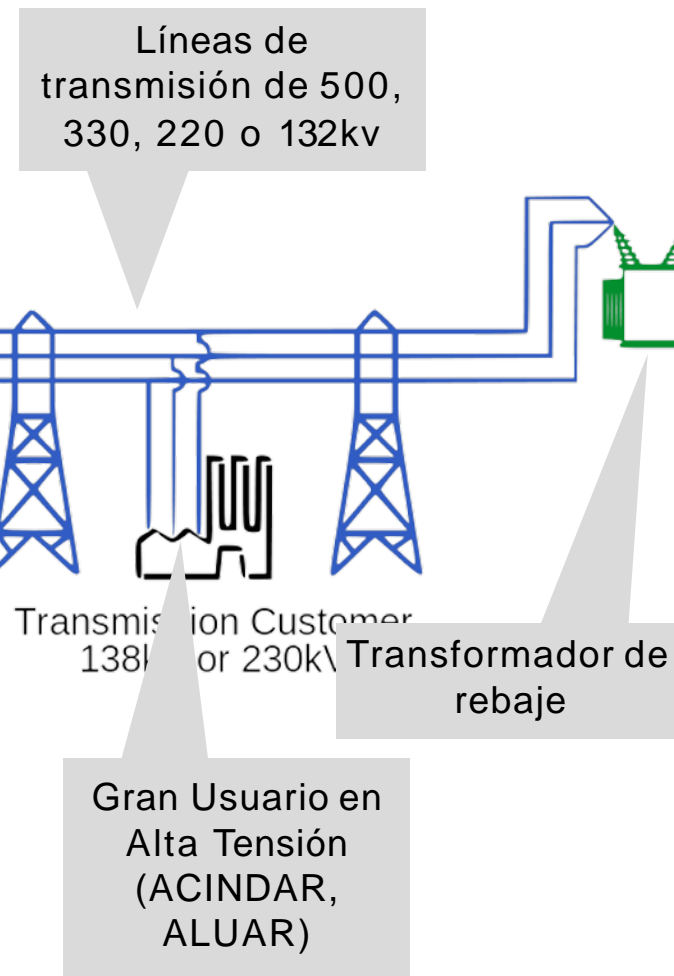
Electrical Systems

General Concepts

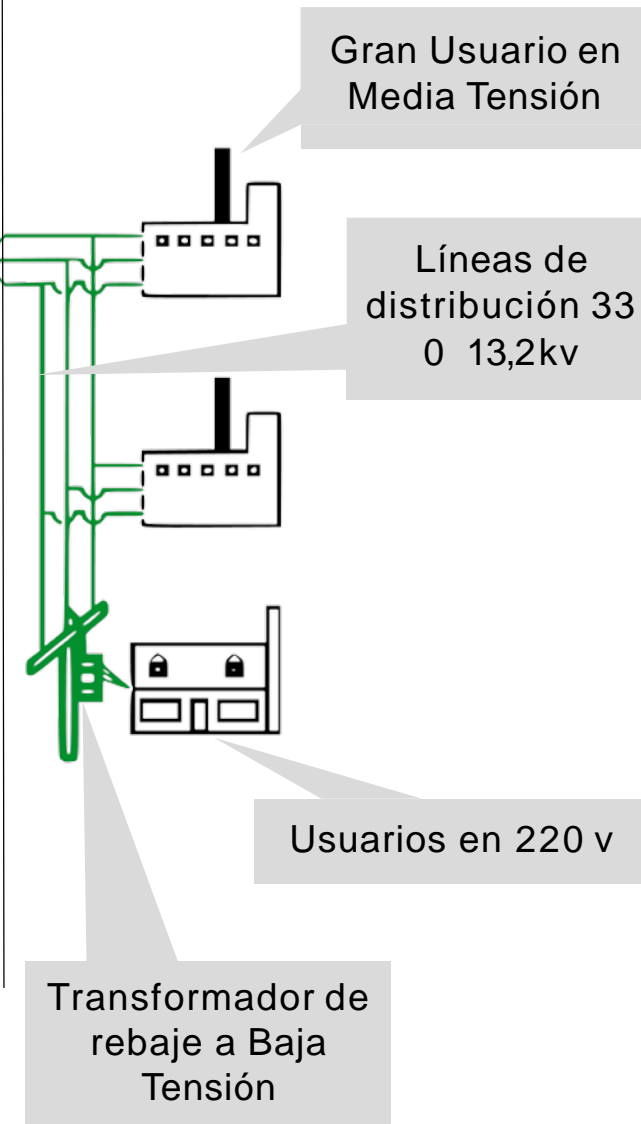
GENERACIÓN



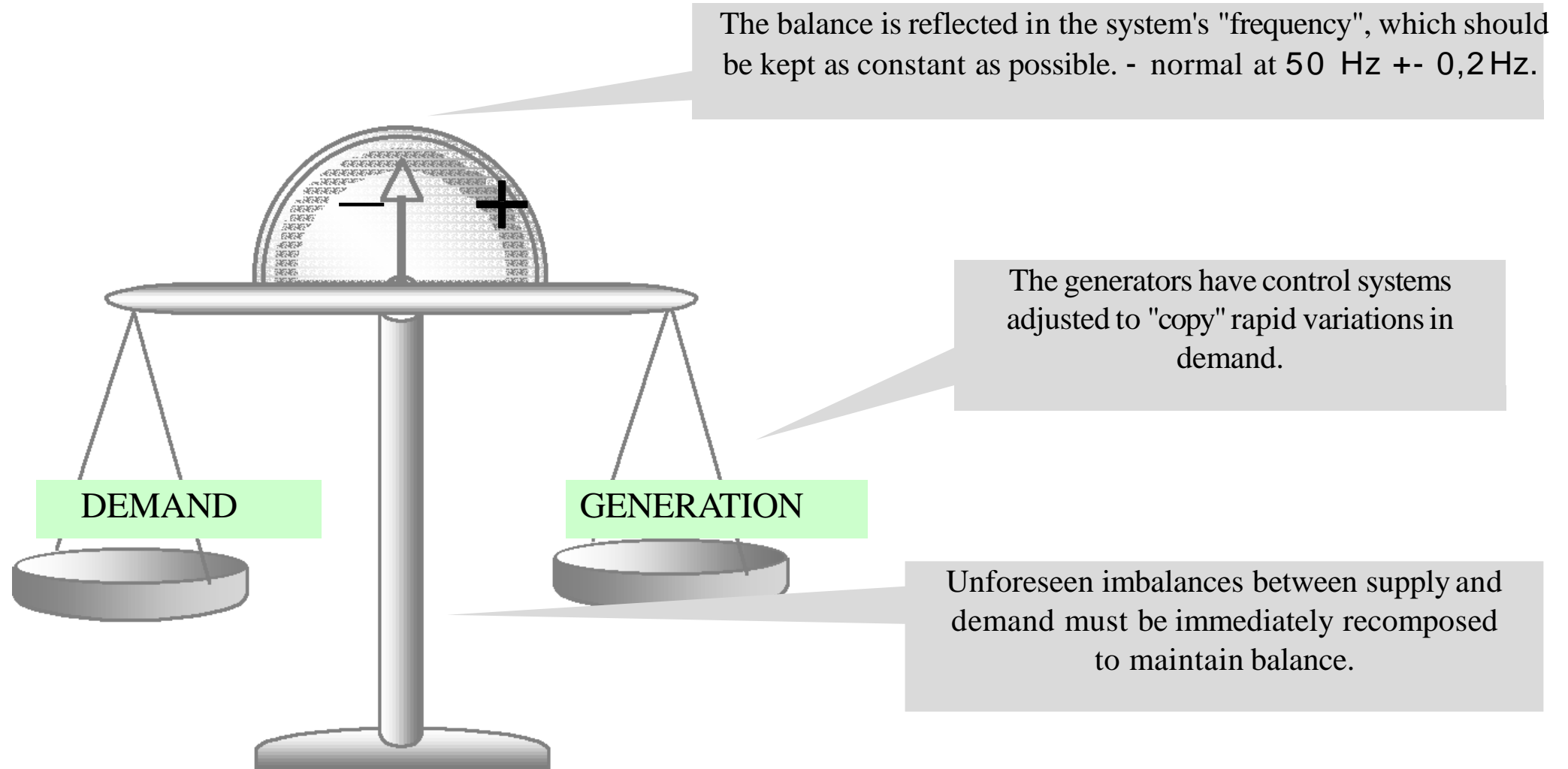
TRANSPORTE



DISTRIBUCIÓN



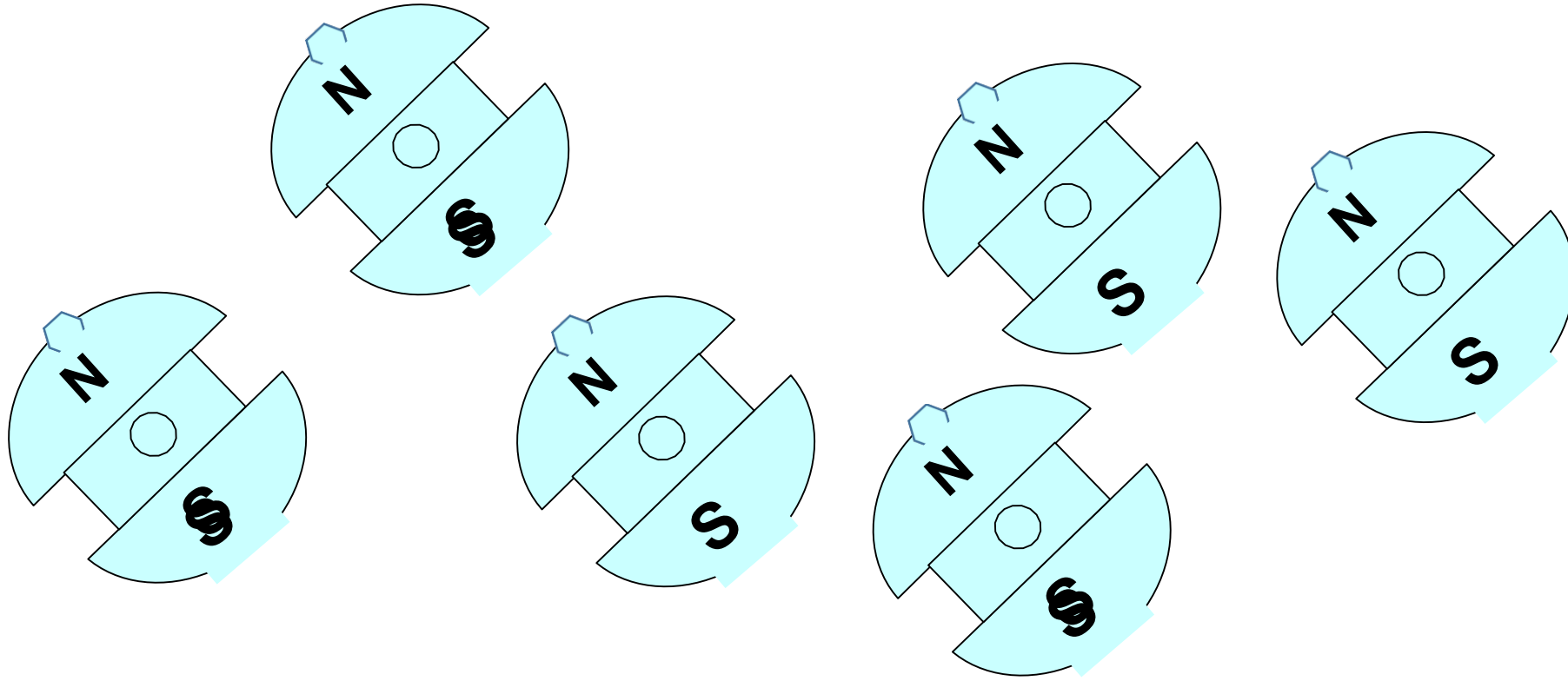
- At all times, the generation should be equal to the demand.
- The demand varies randomly instant by instant.
- The generation varies accordingly to cover the demand.



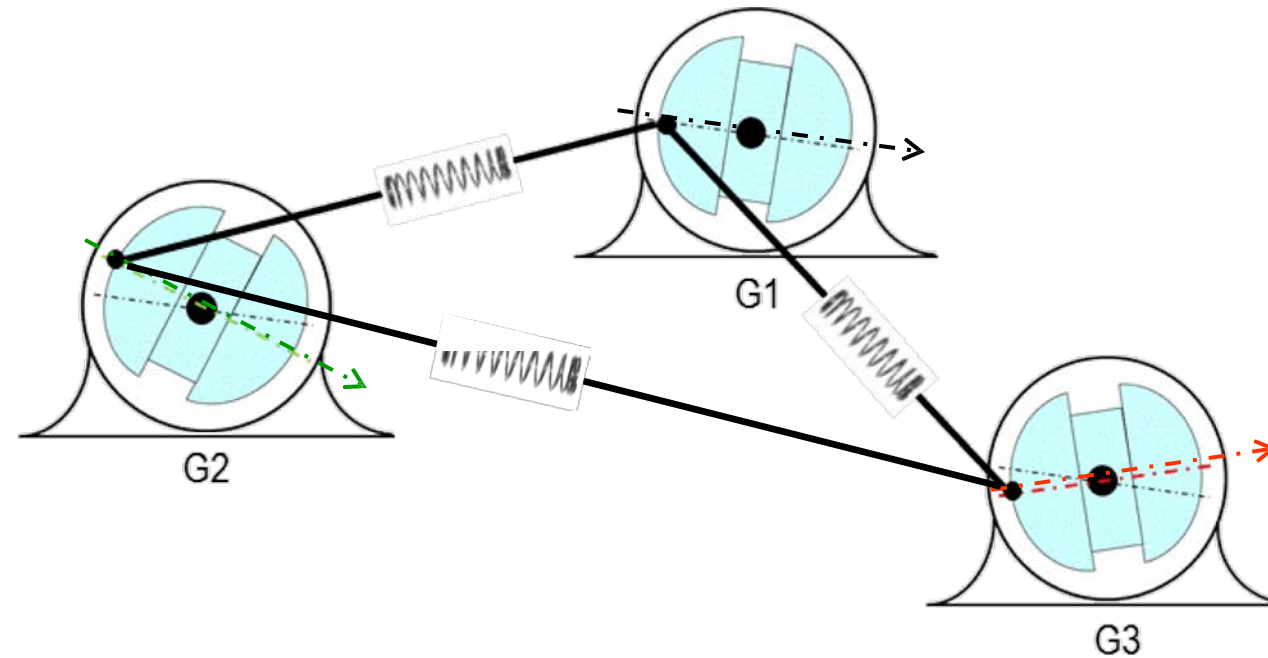
The rotors of a generator in an interconnected system rotate all the same as if they were coupled to a connecting rod



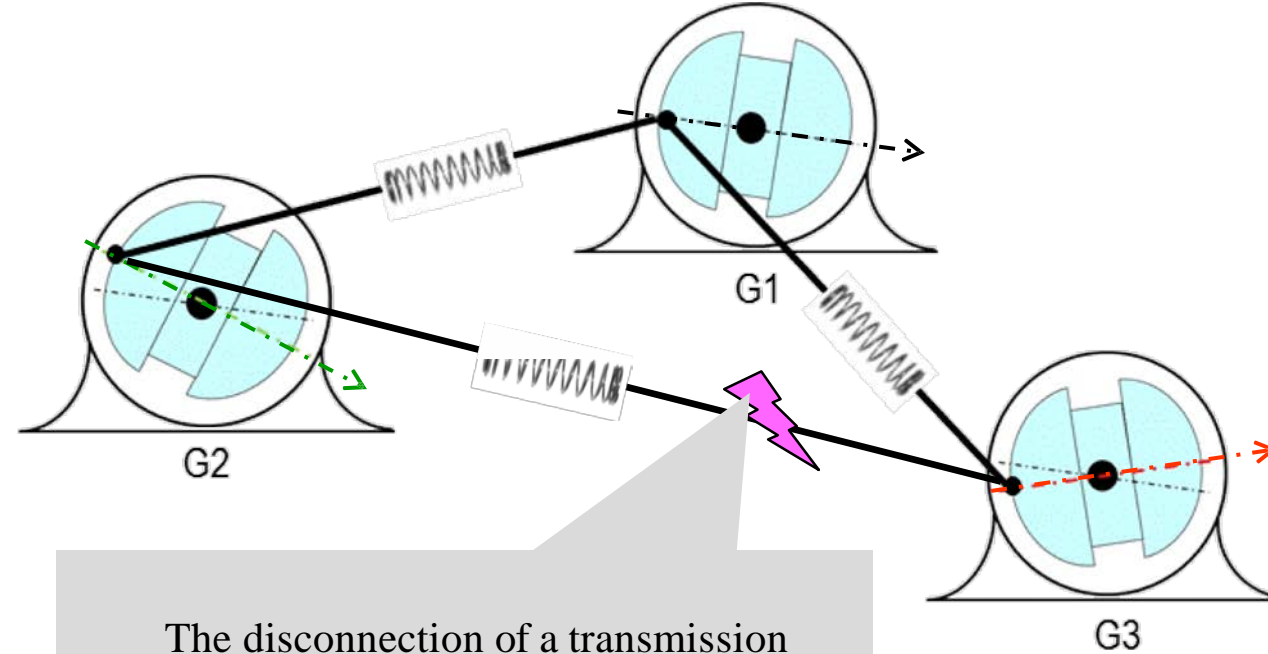
Connecting rod for 6 wheels to turn the same



- All generators rotate in synchronism.
- For example, a 2-pole generator rotates at 3,000 rpm.
- This equals 50 turns / second (hertz, Hz) = 50 Hz.
- The "electric speed" is the same in all generators.



- The power grid consisting of transmission lines, transformers, series capacitors, etc. it does not contain a rigid "connecting rod", but instead an interconnected virtual spring.



The disconnection of a transmission line is equivalent to a spring that is cut
 \Rightarrow possible loss of synchronism.

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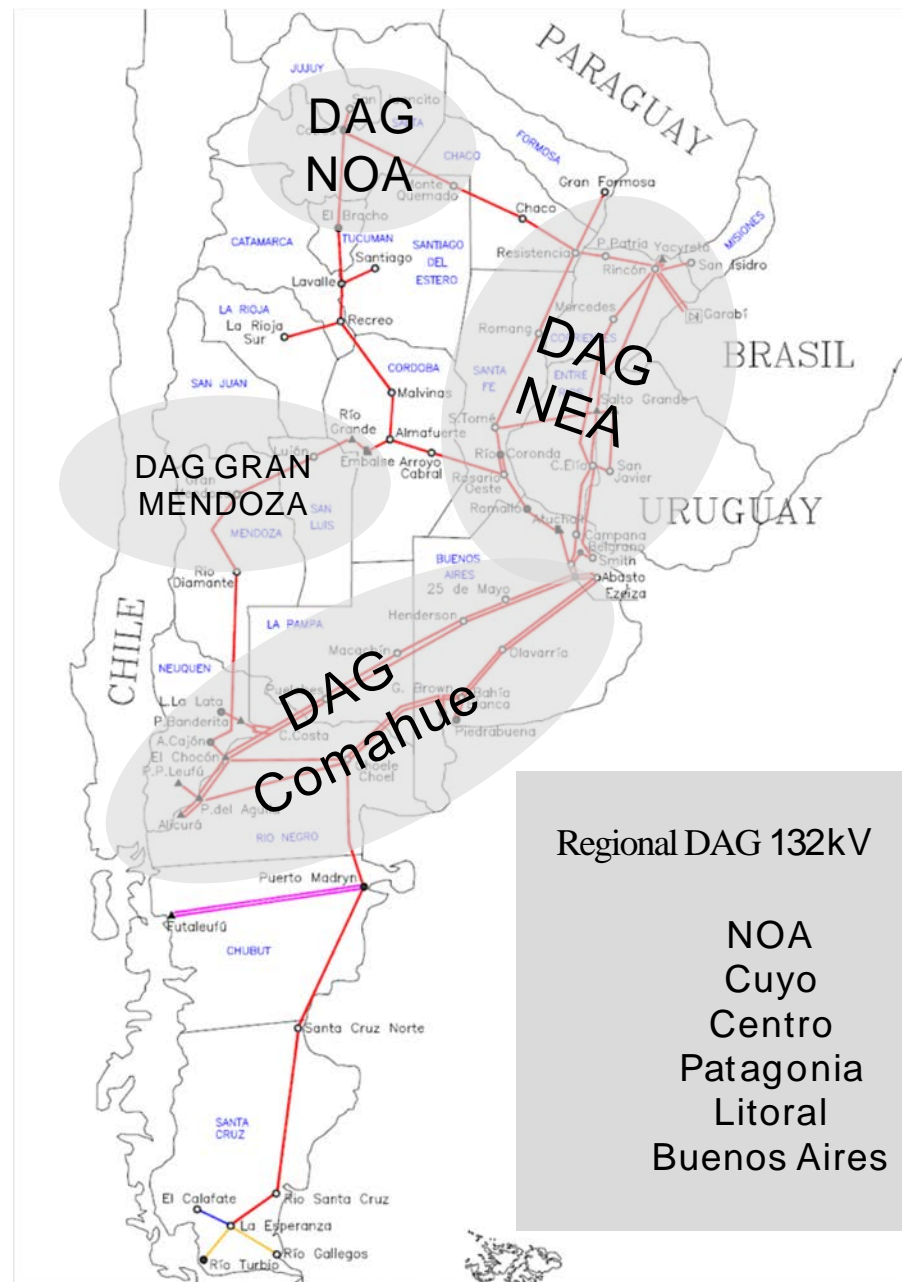
- Precautions for equipment safety: power equipment
 - a) (generators, lines, transformers) connected to the network have protective measures that act when the parameters of the network are out of the ordinary (voltage, frequency, temperature, pressure).
- Precautions for the security of the System: SADI has mechanisms to act against significant network or generation failures.
 - a) Disconnect the offer: Automatic DAG Generation Disconnection.
 - b) Cut the demand: Scheme of relief of loads by sub-frequency (“distributor relays”).

The DAG system allows one to intelligently control the disconnection of a transmission line by automatically disconnecting the Generator(s) to keep the system stable after the failure.

The scheme is widely used in different parts of the world (Brazil, United States, Canada), and in particular in regions where generation and demand are joined with high-voltage transmission systems of great length (> 1,000 km).

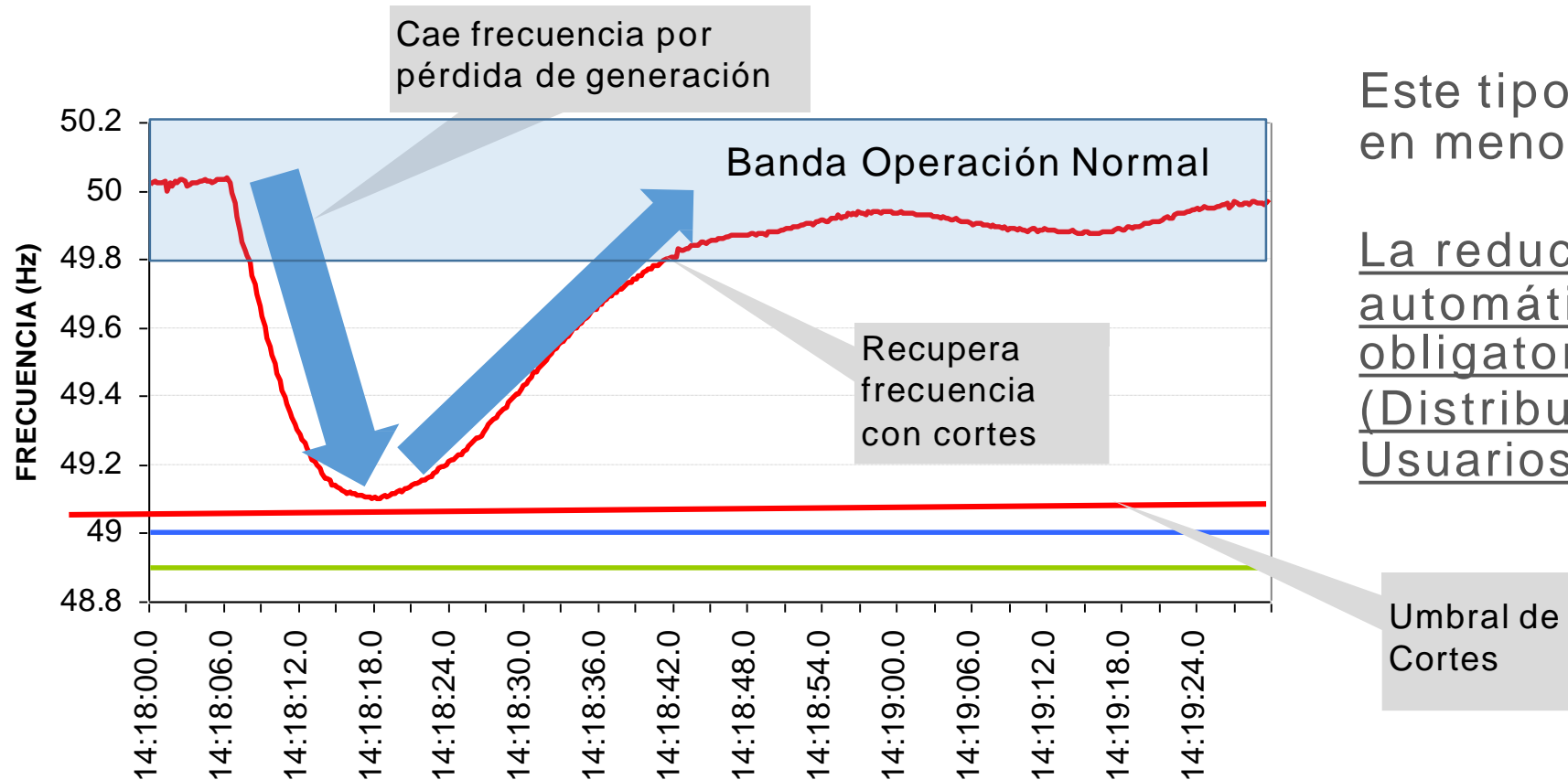
In Argentina it has been used for more than 40 years at both the 500 kV level (Transener) and at the regional transmission level (regional carriers).

The management and operation of DAG systems is carried out by the Carriers where they are located.



Cortes de demanda: Sistemas de control (Relés de alivio de carga de las distribuidoras)

Cortes instantáneos que actúan cuando el desbalance entre generación y demanda hace que la frecuencia baje de valores normales y tiene por objeto recuperar la frecuencia. El esquema de alivio de cargas por subfrecuencia tiene que estar preparado para cortar al menos un 50% de la demanda abastecida. La pérdida máxima de oferta debería ser en ese caso del orden del 40%.

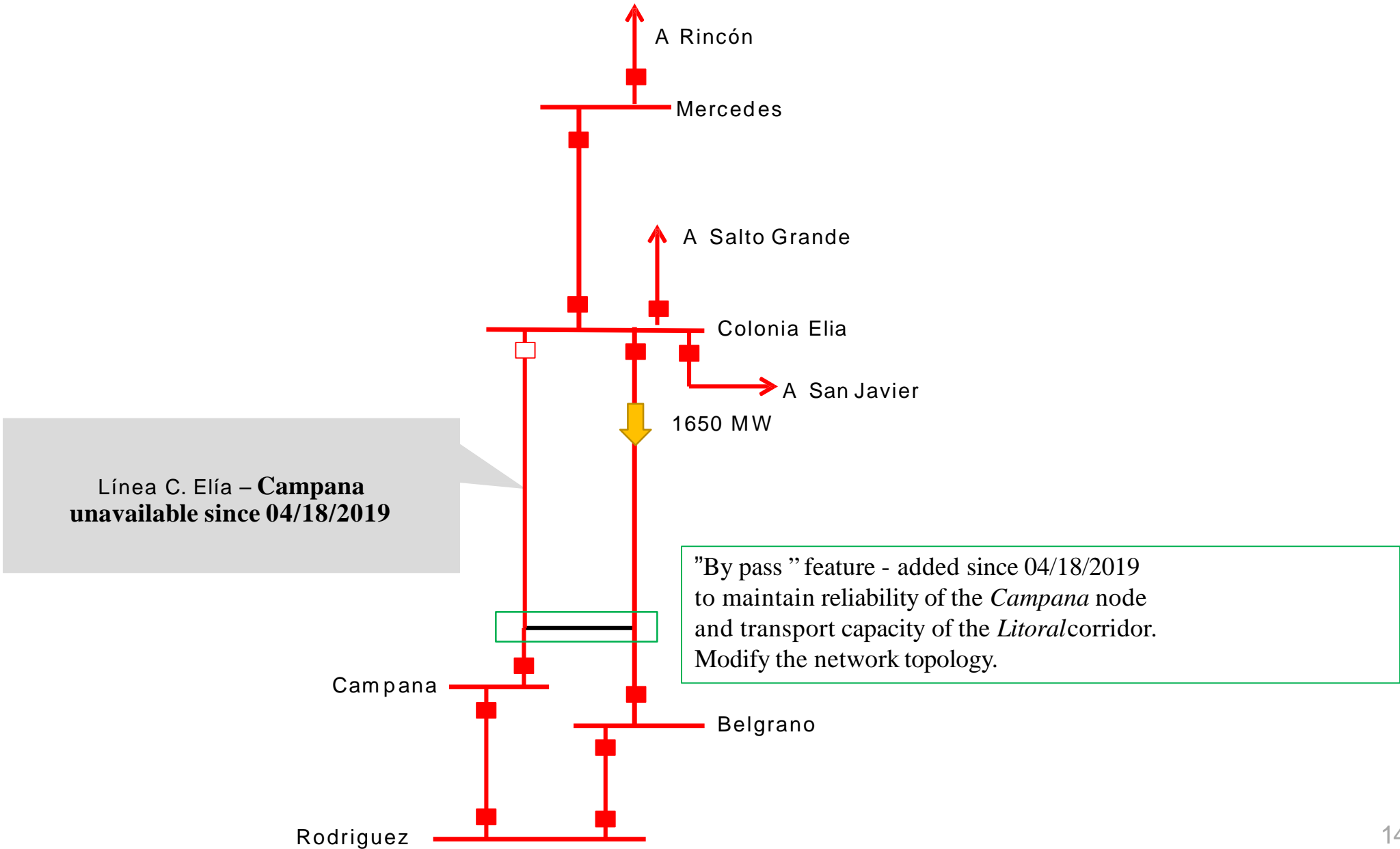


Este tipo de eventos se desarrolla en menos de 30/40 segundos.

La reducción de demanda es automática (relés de alivio) y obligatoria para toda la demanda (Distribuidoras y Grandes Usuarios) del SADI.

SADI Failure – 16J

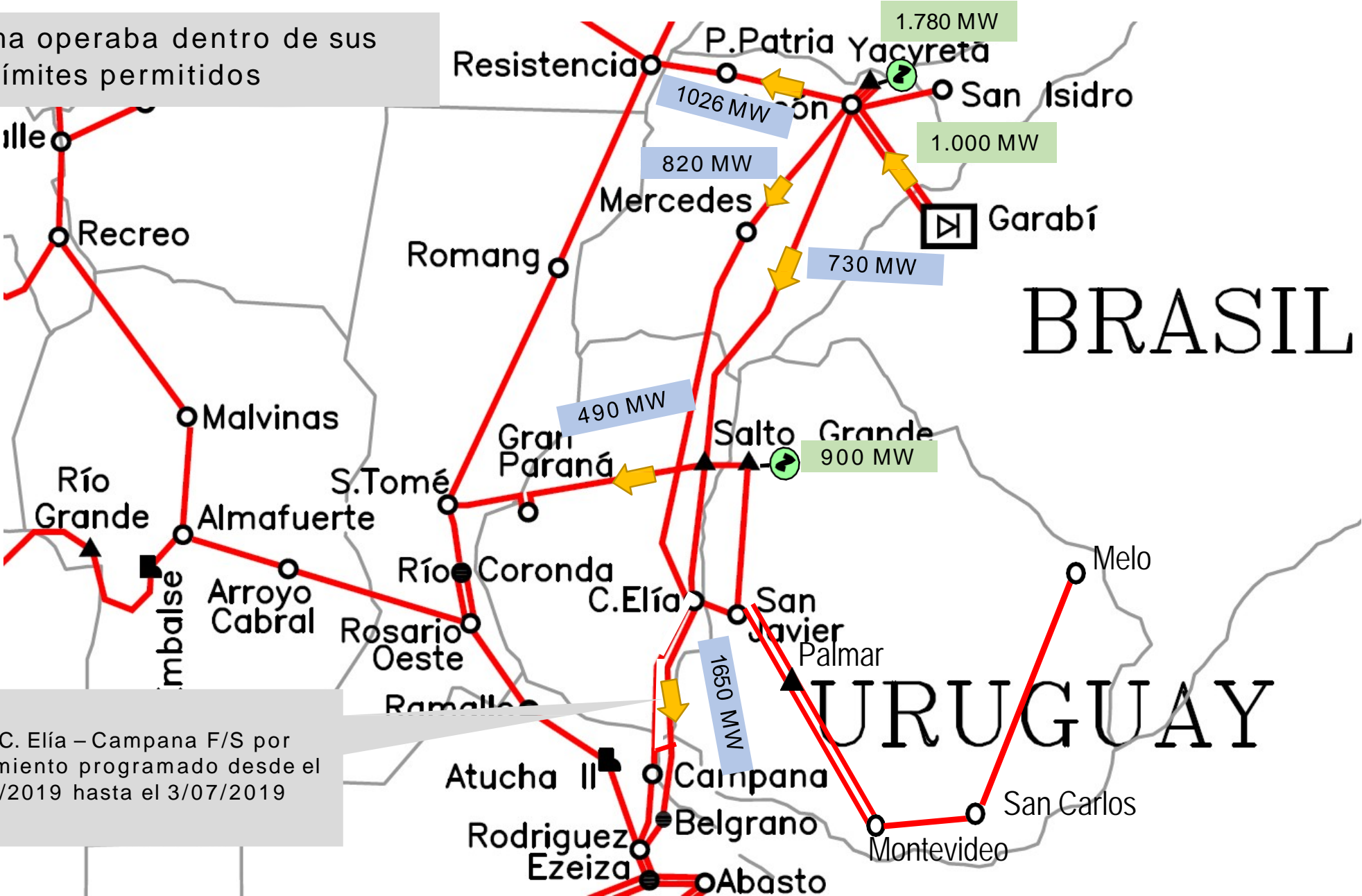
General Concepts



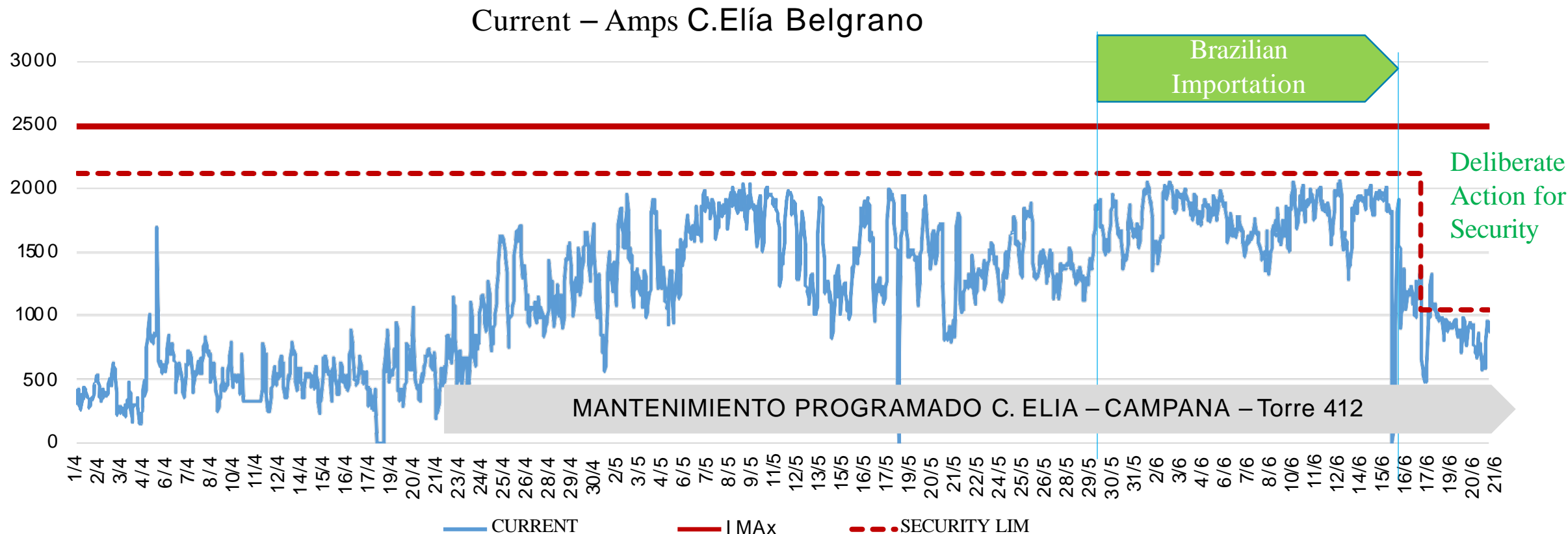
El sistema operaba dentro de sus límites permitidos

Generación

Transmisión

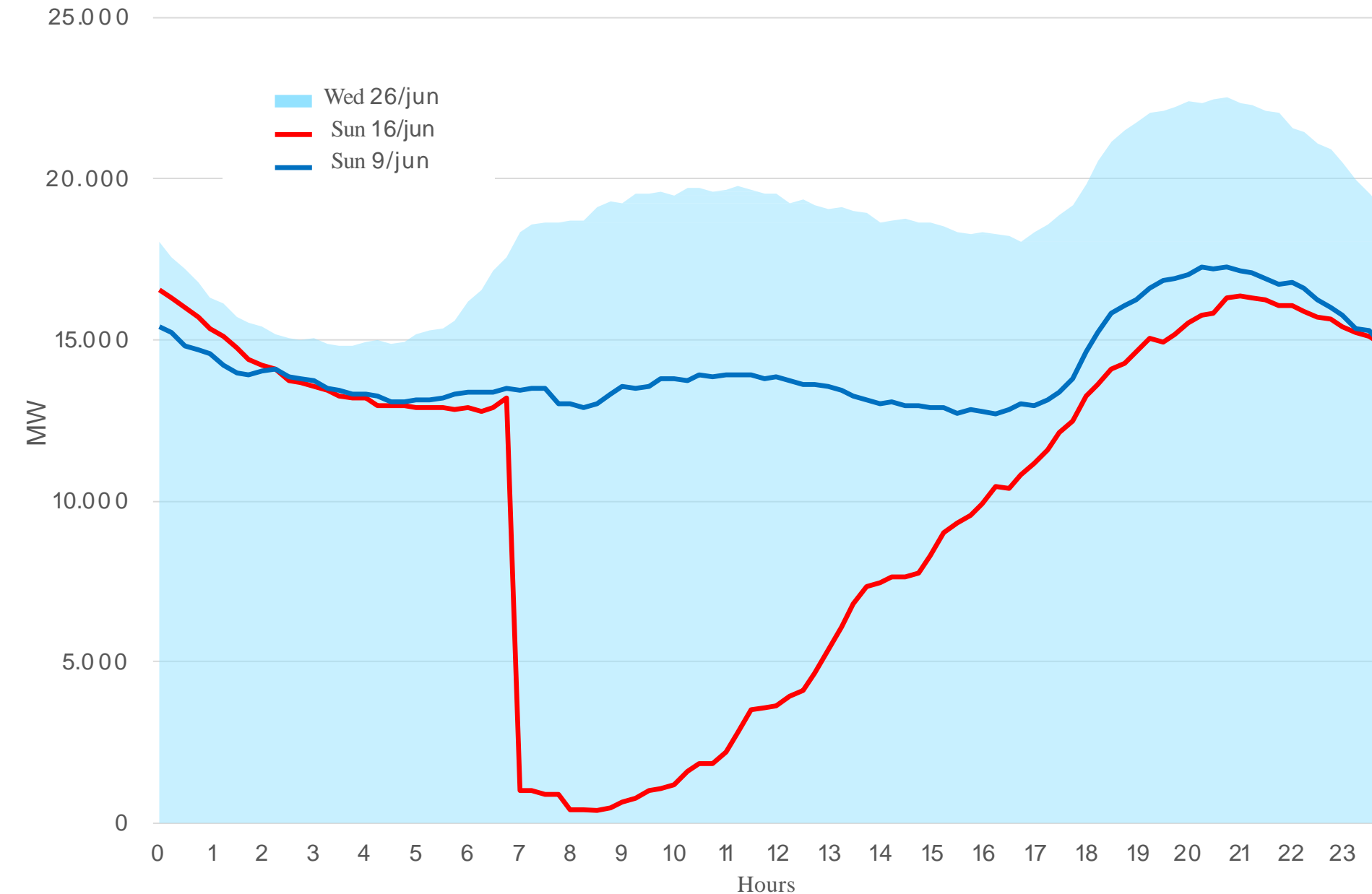


Línea C. Elía – Campana F/S por mantenimiento programado desde el 18/04/2019 hasta el 3/07/2019



Throughout this period, SADI was operated in compliance with the established safety limits. In the moment prior to the failure, the contribution of Brazil allowed the supply reduction in Yacyretá.

UNLP: “The generation office was according to the limits of the corridor. There was no overload of too much import from Brazil.”

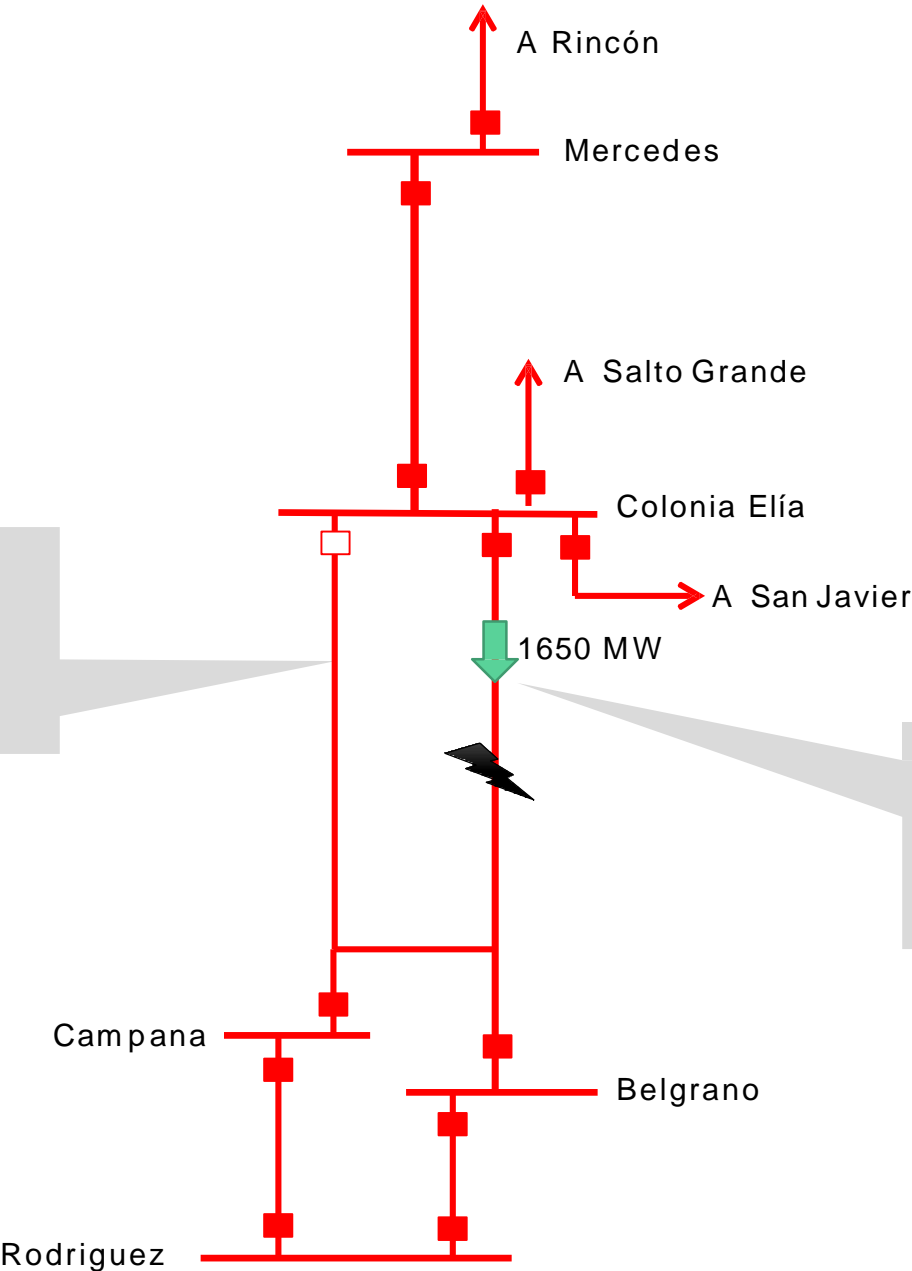


The failure occurred early Sunday morning where demand was very low.

The demand at that time (approx. 13,200 MW) was 70% of the average demand for one business day and 50% of the historical record recorded.

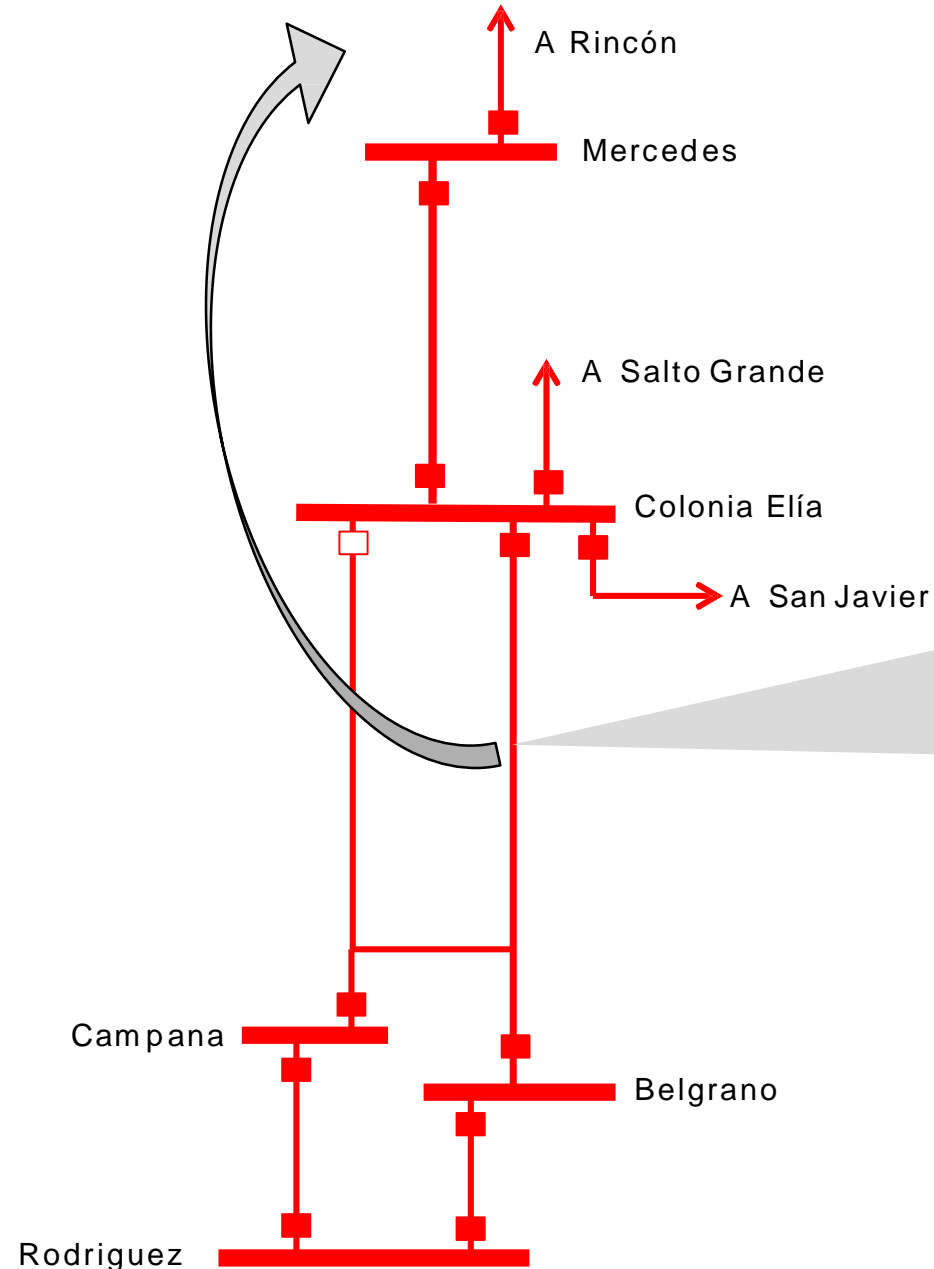
7:06:24

Line C. Elia - Campana
available since 04/18/2019



07:06:24
Short circuit in the line Colony Elia
- Belgrano

7:06:25



El desenganche de esta línea debería enviar la señal de DAG.

Transener confirmó que no hubo actuación de DAG por falta de reprogramación cuando se realizó el bypass para adaptarlo a la nueva topología.

Separación isla NEA - litoral - GBA

Hora	Evento significativo
07:06:24	Cortocircuito monofásico Colonia Elía—Belgrano. Desenganche y caída de demanda.
07:06:25	Falla de DAG por 1.200 MW. Señal no llegó a generadores. Exceso de generación.
07:06:26	Pérdida de sincronismo de Yacyretá y Salto Grande Respecto de SADI por falta de DAG. Oferta > demanda.
07:06:26	Separación del SADI (isla) de Yacyretá, Salto Grande, Misiones y Uruguay. Pérdida de 3.200 MW de la generación. Desbalance y descenso de frecuencia del SADI.



Desbalance definitivo

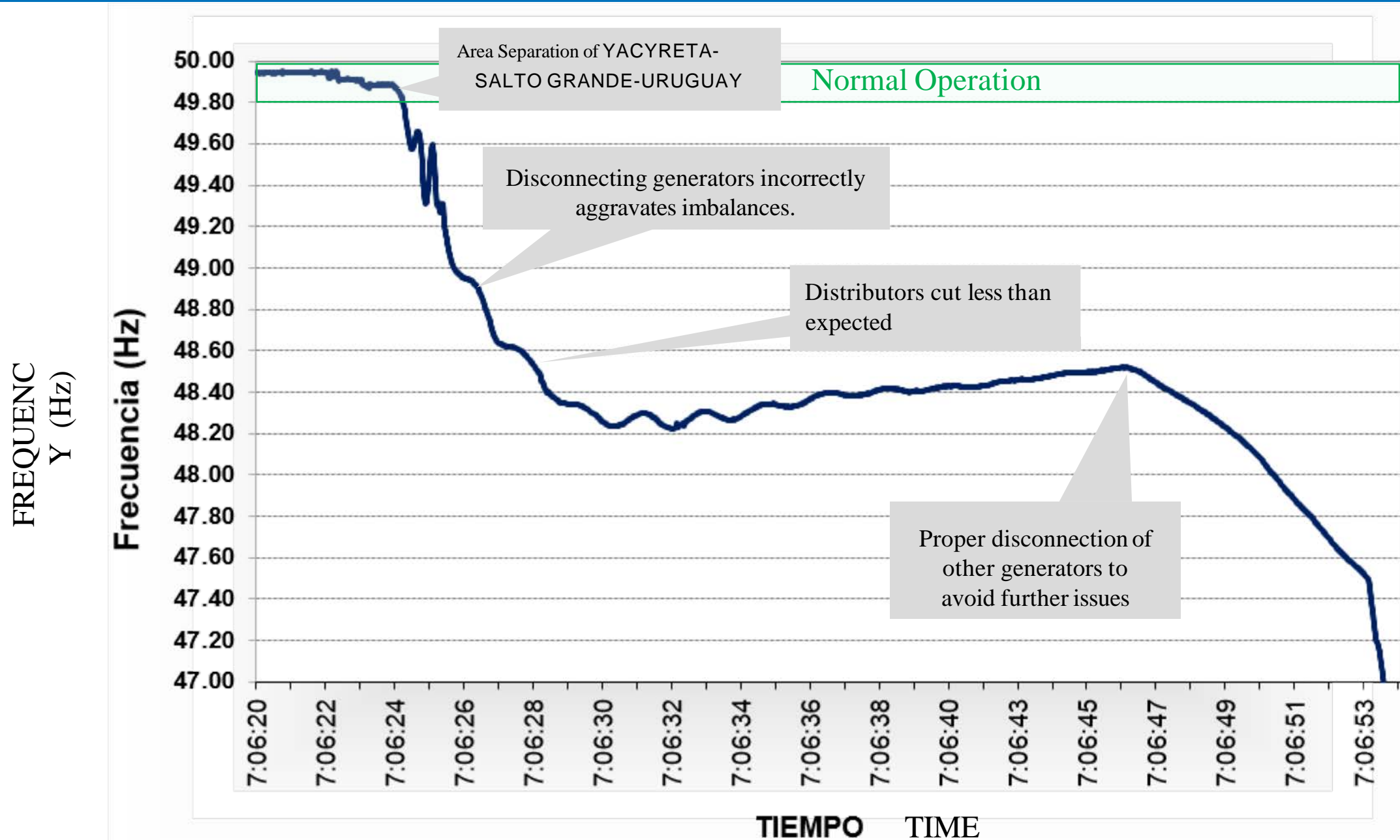
Hora	Evento significativo
07:06:24/30	Alivio de carga por subfrecuencia menor al previsto (1.500 MW).
07:06:30/36	Desenganches prematuros de oferta x 1.500 MW menor al previsto (Nuclear Embalse + Térmicos)
07:06:30/53	El SADI quedó desbalanceado fuera de rango operativo.
07:06:54	Desenganches de máquinas para protección: cortes totales en el SADI

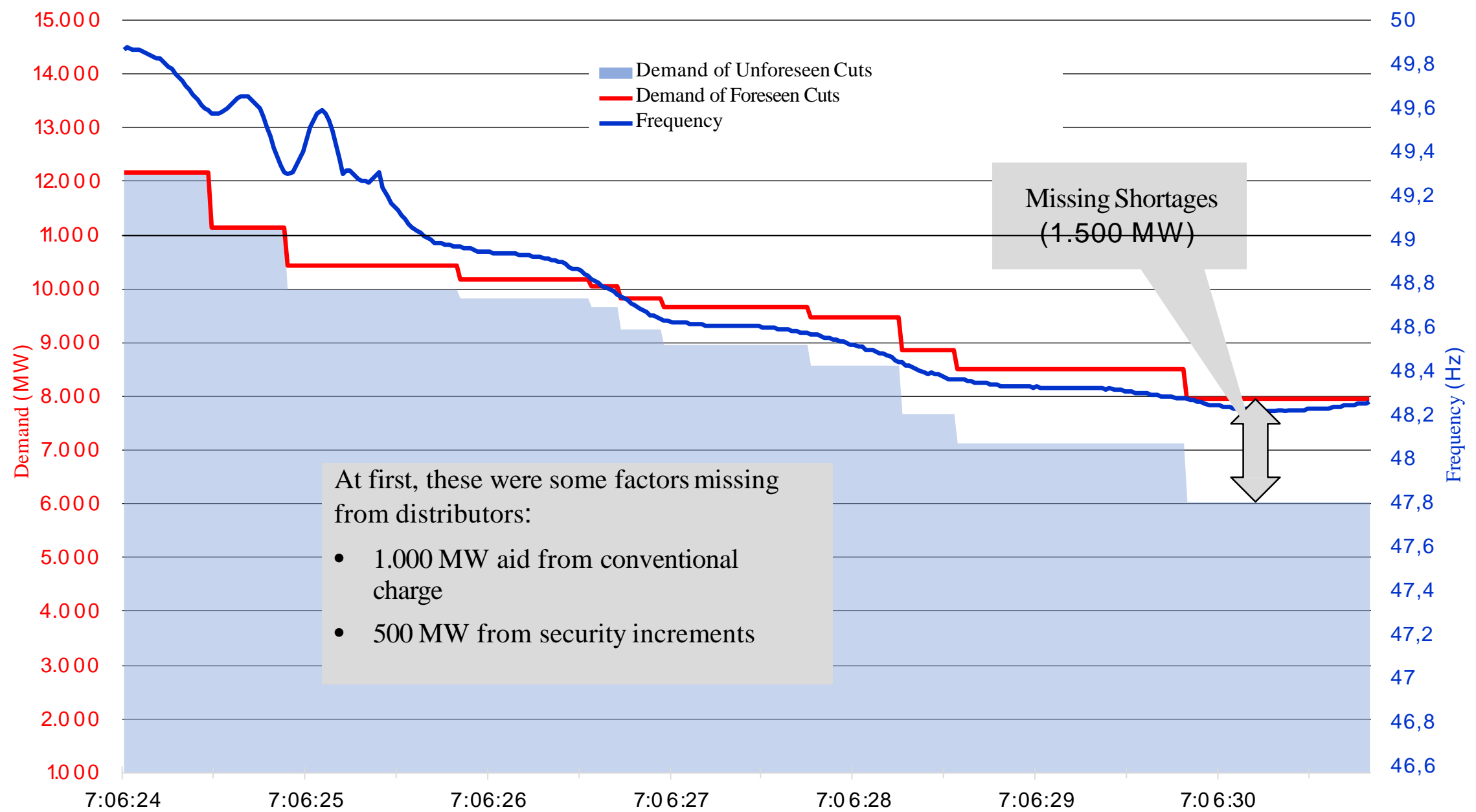
El resto del SADI perdió un aporte de aproximadamente 3.200 MW se generó un desbalance de 4.700 MW (38% de la generación)



UNLP:
 “En los primeros instantes (20 segundos) parte de los generadores remanentes en el SADI se desconectaron por actuación indebida de sus protecciones”.

“[A su vez], no actuaron todos los dispositivos automáticos de desconexión de carga de las distribuidoras y grandes usuarios. Como resultado, el SADI llegó al colapso en el término de 20s a 30s. Si no hubieran salido indebidamente los generadores y se hubiese desconectado la carga prevista, no se hubiese alcanzado la condición de colapso”.





Hour	Significant Event
07:06:24	1 Single phase short circuit Colonia Elía — Belgrano: Disengagement and fall in demand.
07:06:25	2 DAG failure for 1,200 MW. Signal did not reach generators: Generation excess
07:06:26	3 Loss of synchronism Yacyretá and S. Grande Regarding SADI due to lack of DAG: supply > demand
07:06:26	4 Separation of the SADI (island) from Yacyretá, Salto Grande, Misiones and Uruguay. 3,200 MW loss of the generation. Greater imbalance and decrease in frequency of the SADI.
07:06:24/30	5 Distributors: Relief of subfrequency load less than expected (1,500MW).
07:06:30/36	6 Premature supply disconnections x 1,500 MW less than expected (Nuclear Reservoir + Thermal)
07:06:30/53	7 SADI was unbalanced out of operating range for more than 20 seconds.
07:06:54	8 Machine unhooks for protection: total cuts in the SADI

- “There was an unexpected line disconnection (normal event)”
- The non-performance of the DAG mechanism “of the transport company, which in this circumstance should disconnect some generators,” caused that “two other lines were disconnected, producing a major disturbance”
- “If the generators had not gone out improperly and the expected load had been disconnected, the collapse condition would not have been reached”

UNLP
REPORT

1. Wholesale Electricity Market Agents (Transporters, Generators, Distributors, Large Users) provide CAMMESA with reports when a failure occurs; In this case, due to the complexity of the event, they are around 350 reports.
2. The technical areas of CAMMESA perform the analysis until a final report is consolidated based on the available information.
3. Immediate corrective actions are established and implemented.
4. Both Agents and CAMMESA send their reports to ENRE.
5. Once the responsibilities have been determined, the ENRE will apply the corresponding penalties according to what is established in the regulatory framework.
6. Distributors and Large Users who did not meet the expected load relief will pay compensation proportional to the energy not cut to the Stabilization Fund.
7. In this particular case, given the extension of the event, the SGE takes evaluation action with the assistance of experts in electrical systems (UNLP).

1) Non-performance of DAG NEA TRANSFER

2) Generation disconnection out of range

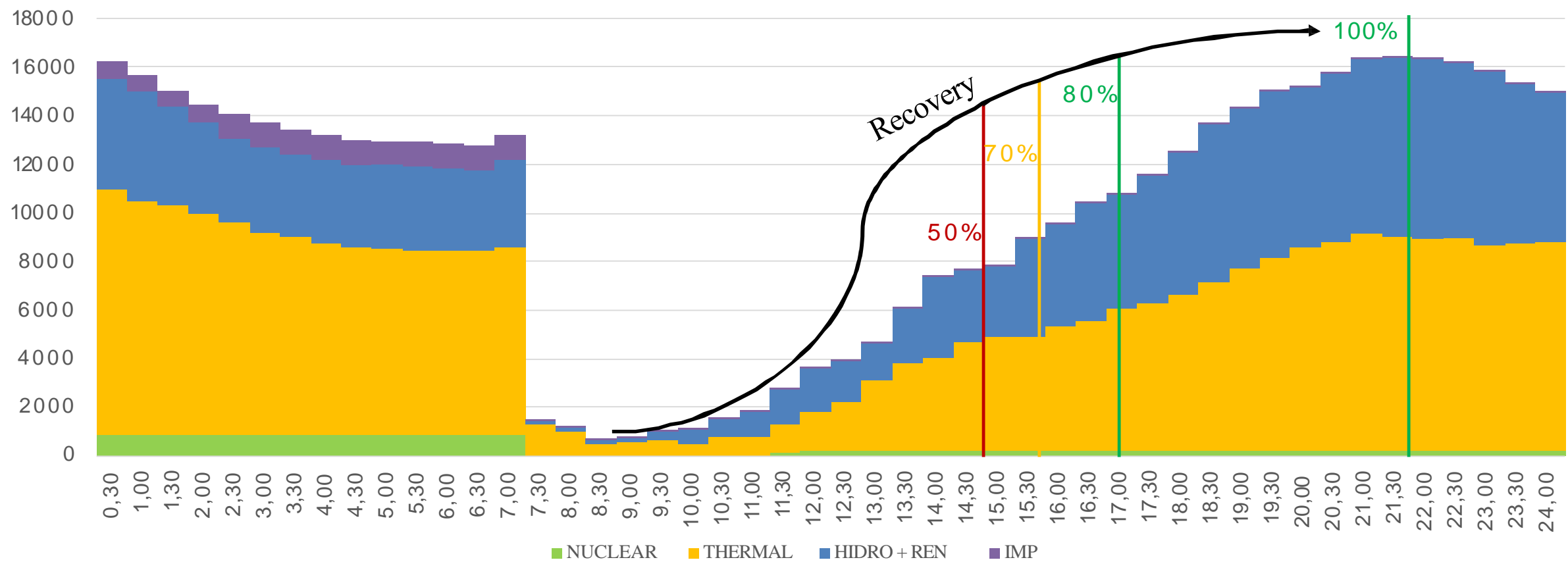
- Some Generators (Preliminarily 5 of a total of 105 rotors of more than 20MW; just over 10% of the generation: CN Embalse, Renova, Termoandes, El Bracho, Agua del Cajón, others?)

3) Insufficient load relief performance

- Majority of Distributors (Preliminarily 69 of 74, cut made approx. 75% of the planned cut)

Service Recovery

Generation by Type



The service recovery was carried out following the steps of PT7 of the Overall Procedures, managing to cover the entire demand at the nightly peak.

Corrective Actions

- **Carrier:** Operation without DAG NEA in case of line failure C. Elía Belgrano, until the line C. Elía - Campana enters (tower 412 - prev 3 Jul).
- **Generators:** Adjustment of protections of those who left the service in advance and review of control procedures.
- **Distributors:** Adjustment requirement of the sub-frequency cut scheme. Online system instrumentation for monitoring of predetermined feeders for cutting.

- The ENRE, once the final reports of all Agents have been analyzed, will establish the corresponding penalties.

- **Transportation:**

- The regulatory framework establishes a maximum of 10% of the sum of penalties on annual compensation and 50% of monthly compensation.

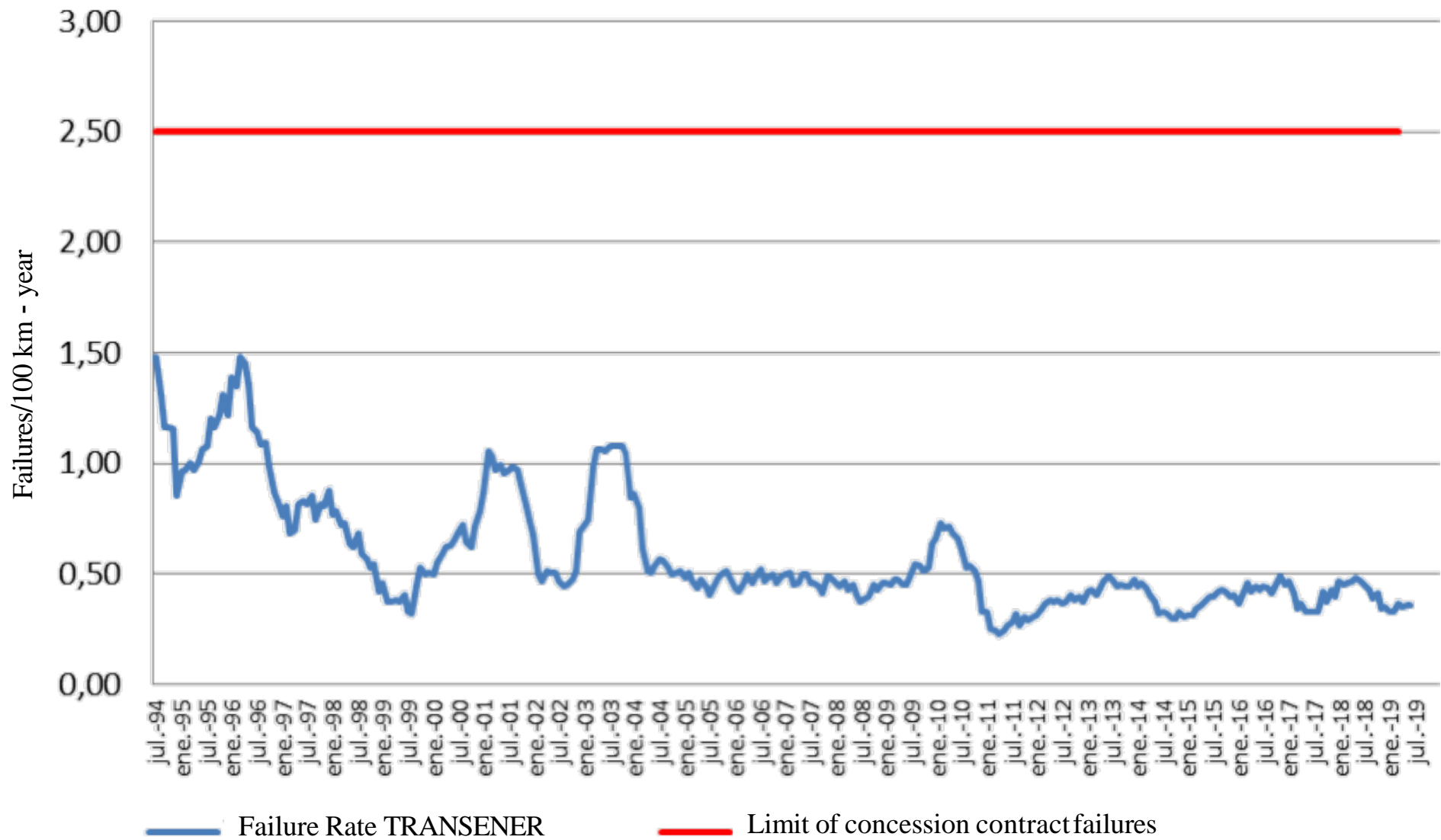
- **Generation:**

- Generators with reduced reliability can be limited in the office and their remuneration is reduced.
- A specific penalty scheme is not regulated, but the ENRE can intervene for special cases.

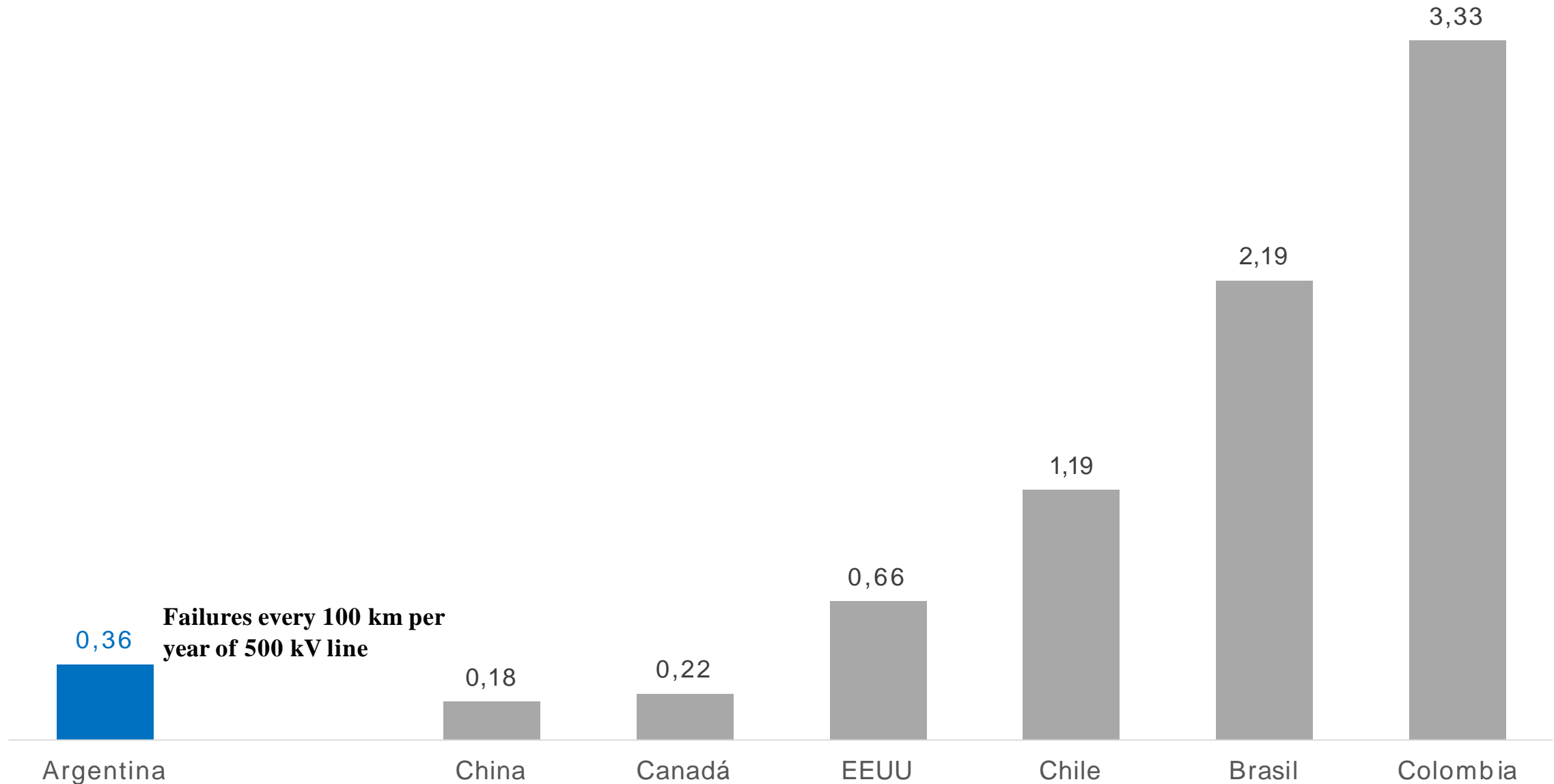
- **Distribution:**

- The performance of the load relief scheme provides for compensation to the cost of energy for the cut not provided during the hours of the interruption.
- To any Distributor or Large User who has not cut the commitment, this penalty is applied directly to the Market through CAMMESA.
- In the failures in which the last cutting step had to act (as in this case), verified the breach the ENRE can intervene and evaluate additional actions.

Comparative performance of SADI over time versus other countries



Annual Closure	dic-08	dic-09	dic-10	dic-11	dic-12	dic-13	dic-14	dic-15	dic-16	dic-17	dic-18	may-19
Failure Rate	0,46	0,64	0,33	0,31	0,38	0,47	0,31	0,41	0,45	0,4	0,35	0,36



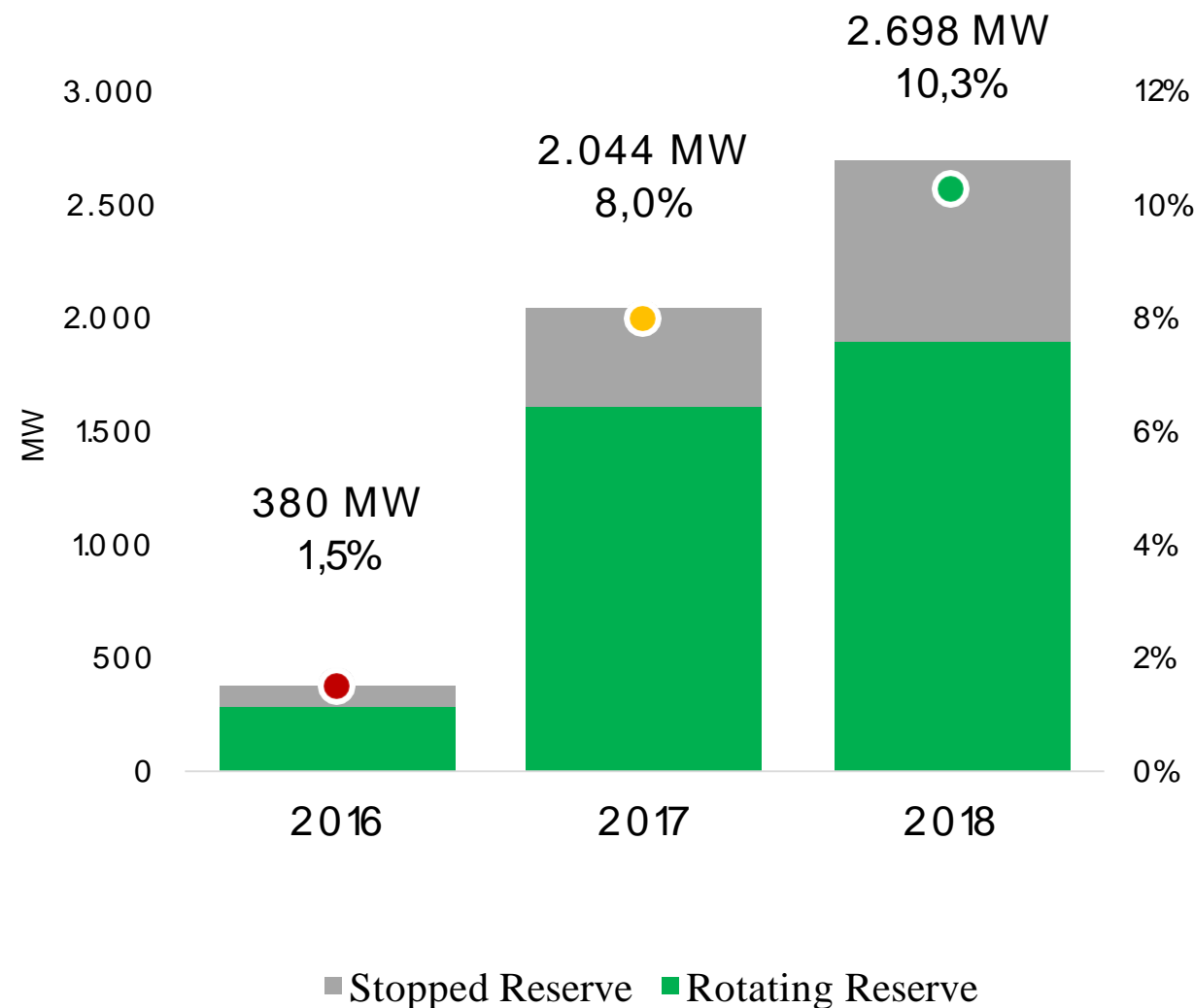
Note: Argentina: Transener as of July 2019. Chile: average of Transelec, Transnet, Colbún and others. Brazil: TAESA and State Grid average. Colombia: ISA.

On average 60 annual failures occur. Around 0.36 failures per year every 100 km @15,000 km (total country - 500kV)

Primary Causes:

- 1) Storms and Wind.
- 2) Insulation Reduction (Humidity and Birds)
- 3) Towers falling due to Tornadoes and strong winds
- 4) Field fires under the lines. Grounding smoke.
- 5) Vandalism

Detail of the operating reserves of the system in hours of maximum annual power demand, 2016-2018.



26.320 MW

SADI's record power demand was reached on 02/08/2018 at 3:35 p.m., with an average temperature in GBA - Coastline of 36.9oC.

From 1,5% to 10,3%

System reserves at peak demand increased from 1.5% in 2016 to 10.3% in 2018.

The minimum revolving reserve is approximately 5% and is required to operate due to variations in demand.

The additional reserve serves to cover unforeseen generation or transport failures without resorting to generation cuts.

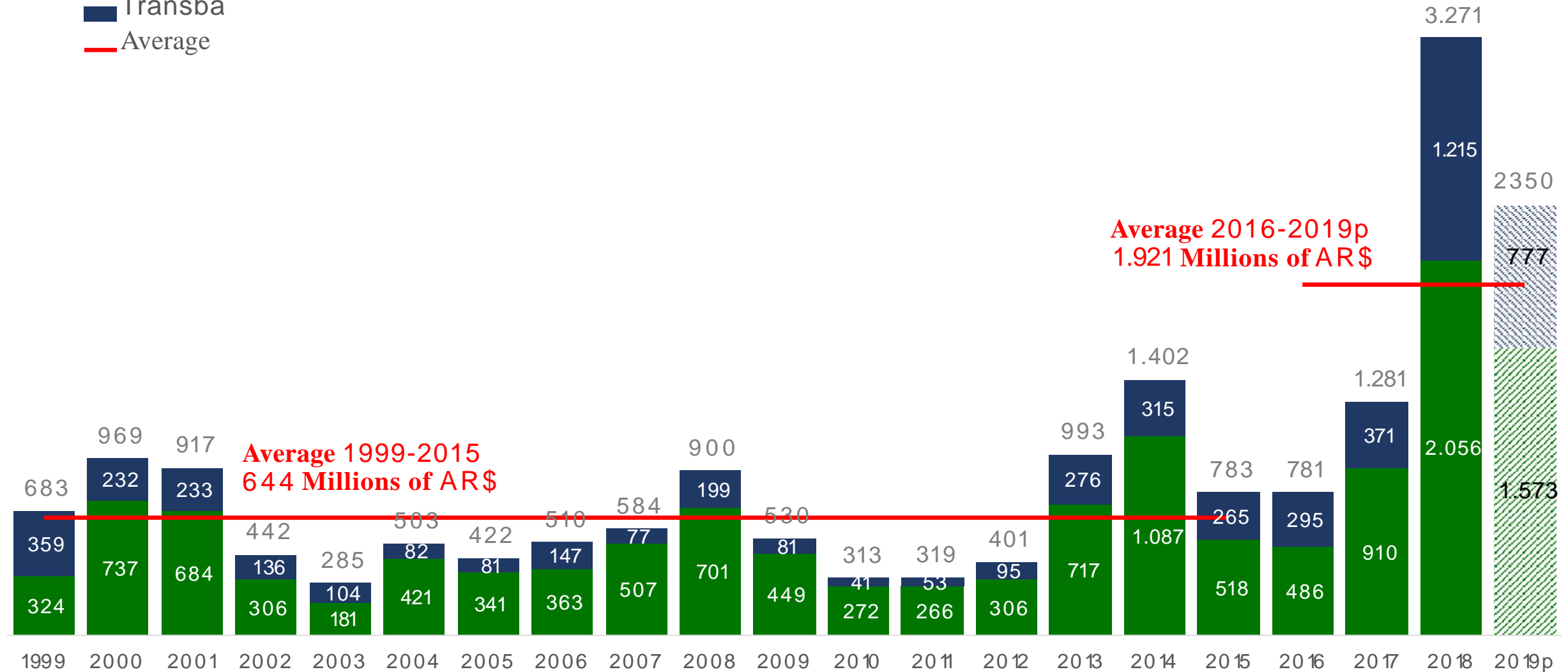
YEAR	ZONE	MW CUTS	POPULATION (MILLIONS)	RESET TIME
1977	NEW YORK & Nearby Areas	6,000	9	26 h
1982	West Coast of United States	12.000	5	
1996	West Coast of United States	12.000	2	
1996	West Coast of United States	28.000	7	9 h
2003	Northeast Coast of United States	62.000	50	3 DAYS
2003	ITALY	24.000	57	24 h
2009	BRAZIL	25000		8 h
2012	INDIA	30.000	350	21 h

ADJUNCTION: TRANSENER INVESTMENTS

Transener and Transba Investments

In millions of AR \$, adjusted for inflation as of June 2019 (est.)

■ Transener
■ Transba
— Average



Transener and Transba Investments

In millions of AR \$, adjusted for inflation as of December 2018

■ Transener
■ Transba
— Average

