LFDD Info session for industrial GUs

Low Frequency Demand Disconnection

January 25th 2024 | Elia

Agenda

1. Introduction
2. Technical concept
3. Frequently Asked Questions
4. Contractual Framework
5. Next steps

Introduction

Context

- Increasing renewables in DSO grids lower the netted demand that can be disconnected in case of a frequency collapse in the European electric grid.
- Elia does not meet the LFDD requirements of the EU netcode E&R[1]
- Elia identified multiple actions to get compliant with the EU legislation.
- The LFDD plan is part of the System Defense Plan that was submitted for approval on 6/10/23 to the Minister of energy.
    - These slides are under assumption that the Minister will approve the system defense plan, which was not yet the case at the moment of this presentation
    - Meanwhile, on 25/1/24 Elia was informed that the Minister has approved Elia's System Defense plan and Restoration Plan

[1] E&R = Emergency and Restoration

Load shedding plan in case of scarcity:

- There is sufficient time to prepare
- Minimize social and economic impact
- Detailed procedure prepared by stakeholders

There is **no need to change** this plan

LFDD plan:

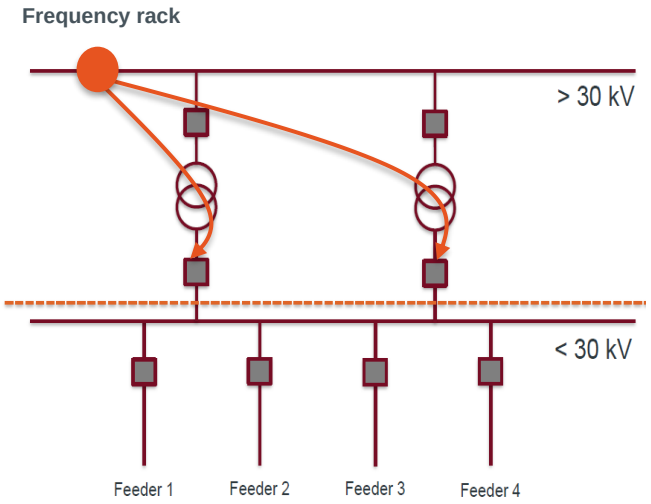
- Technical: system-protection against frequency collapse should work fast and effectively at all times
- Legal: LFDD volume should comply with EU legislation
- Lowest possible social and economic risks
- Transparency for the next 5 years
- Long term strategy beyond 2027

We must **adjust this plan** to protect our system and comply with EU rules

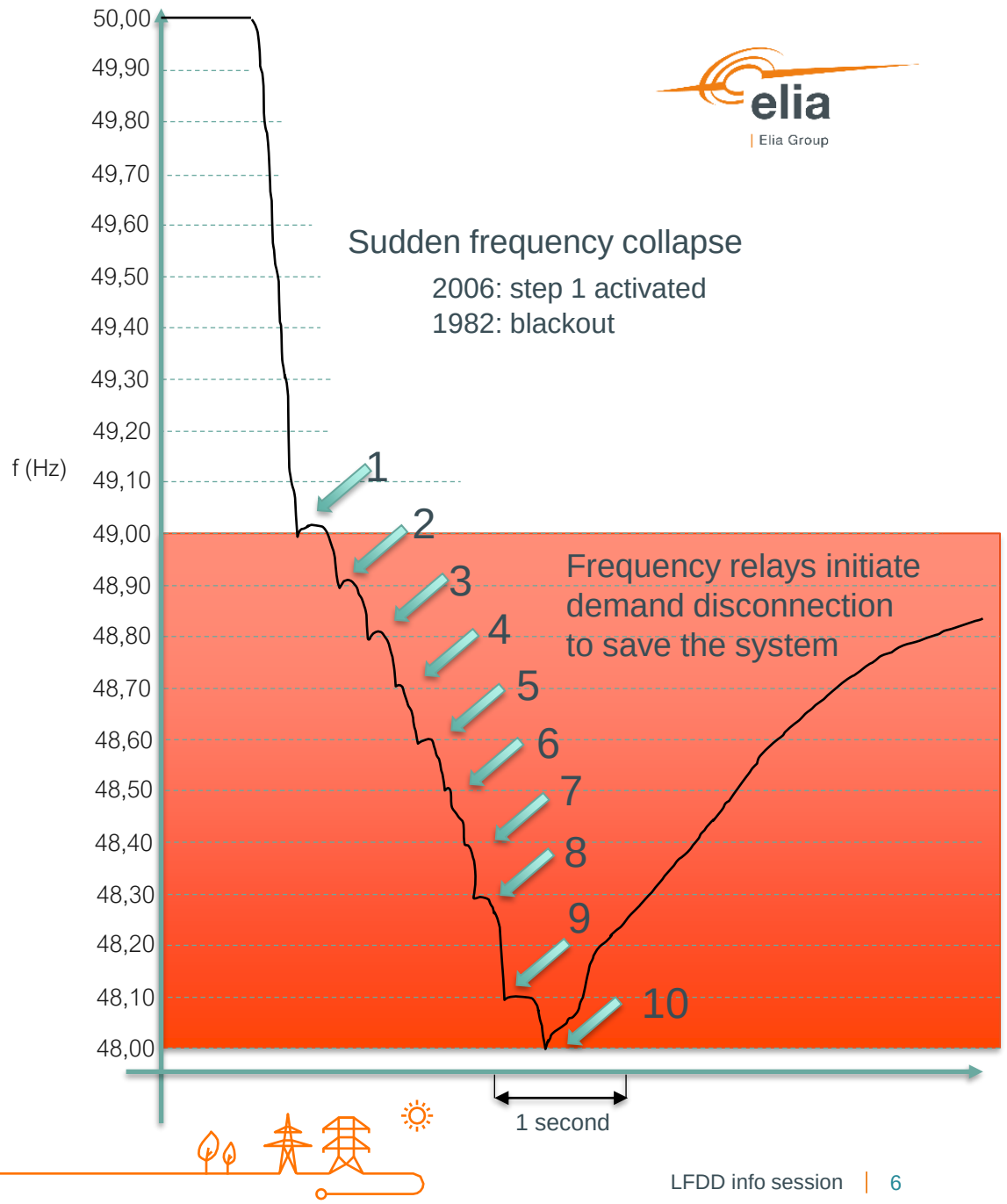
Load shedding
➔ last resort measure = very rare activations
➔ Significant impact, but much less severe compared to a full-scale black-out

Recap of issue with LFDD plan

- Automatic defence measure of last resort to avoid total black-out
- Low-frequency demand disconnection relays are installed over the Belgian territory.
- So far in mainly “rural” communities in DSO grids → 253 substations in 10 steps



- **Manual load shedding plan is not subject of this discussion!**

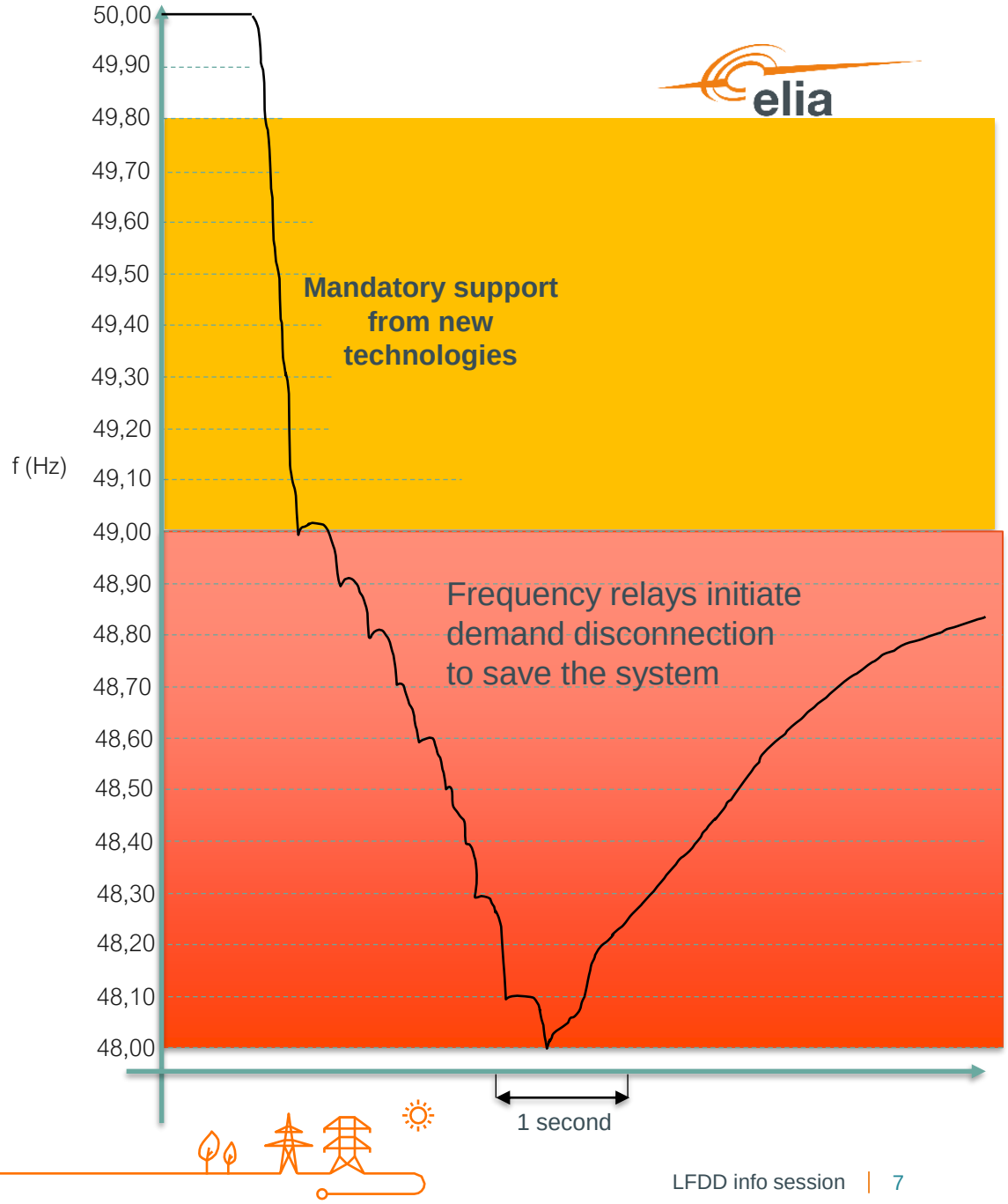


Evolutions in (draft updated) European Network code on Demand Connection

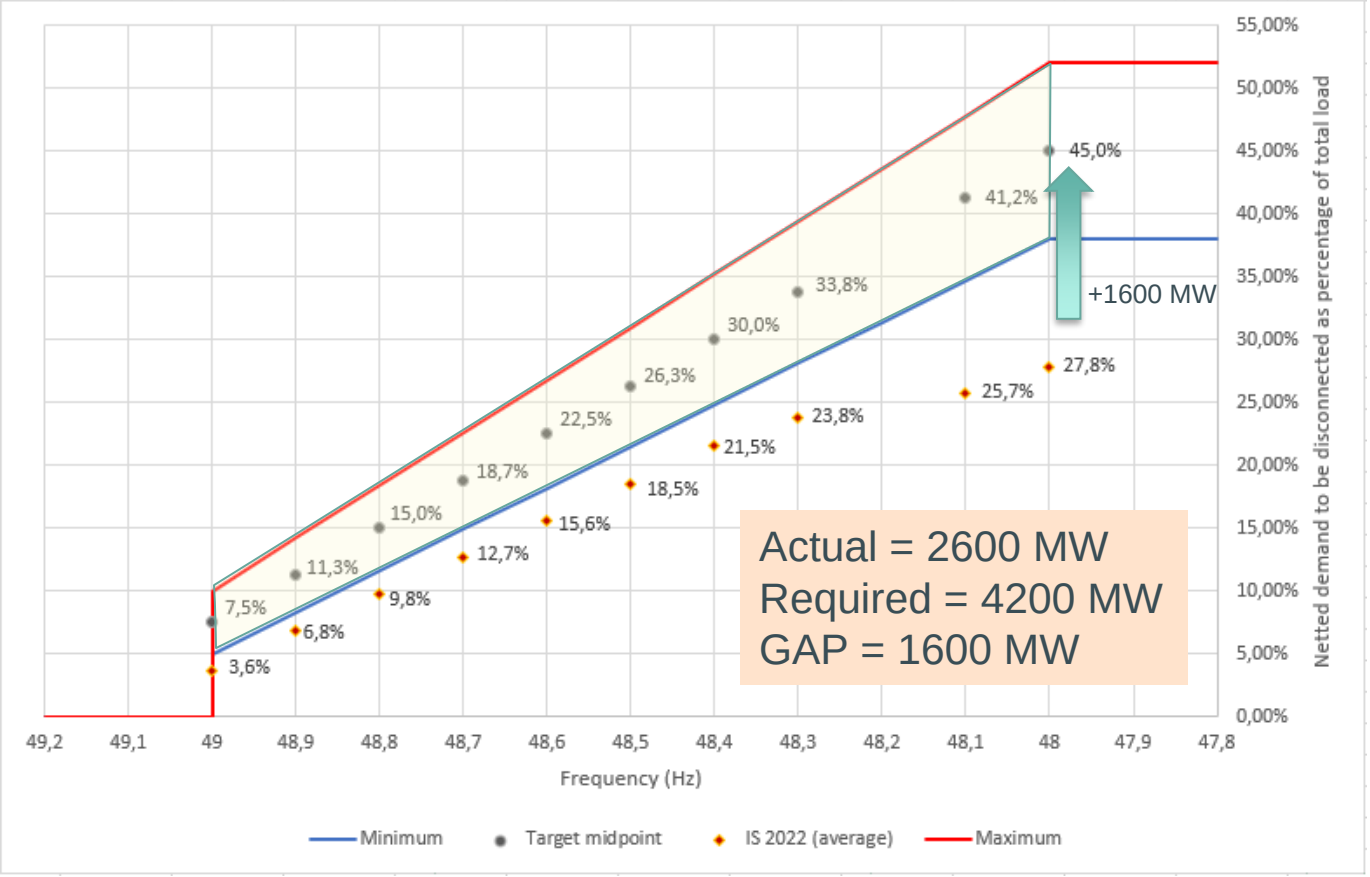
- New technologies (batteries, EV, P2G, heat pumps) should support the frequency in the emergency range (f < 49,80 Hz) before the first load-shedding at f = 49,0 Hz
- Aim is to minimize risks of triggering LFDD and minimize the consequences !
- We follow up the evolutions in EU legislation !

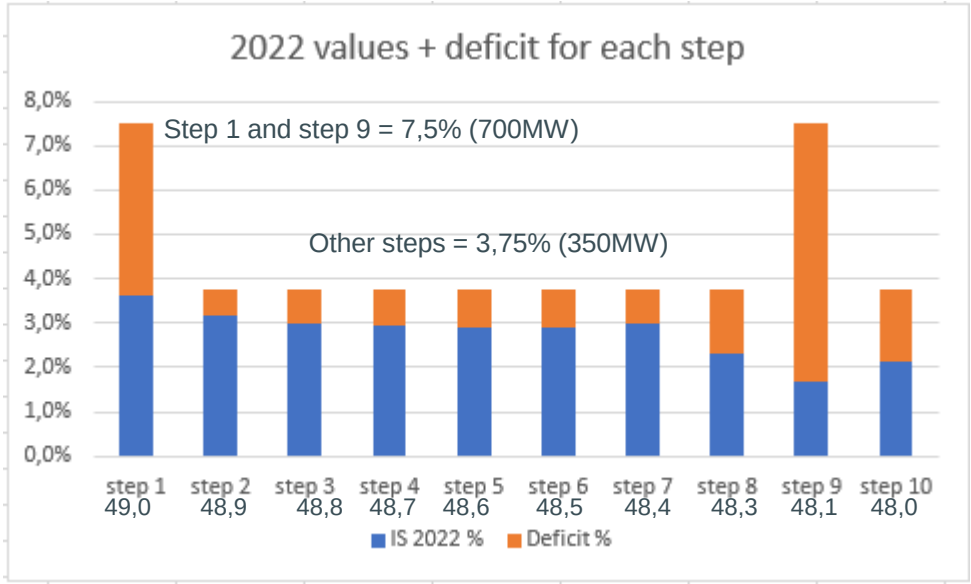
(17) Frequency-related requirements should support the stable operation of the energy system which is being transformed to accommodate the green transition. In the future, the effectiveness of existing low frequency demand disconnection (LFDD) schemes is expected to be reduced due to the increased penetration of distributed generation. Therefore, a new limited frequency sensitive mode for various demand units (LFSM-UC) is being introduced to account for these changes. Furthermore, V1G electric vehicles and associated V1G electric vehicle supply equipment, such as V1G, power-to-gas demand units and heat-pumps are usually technically capable to fulfil such a requirement without negative consequences for the grid user.

LFSM-UC should support the frequency in an emergency case so that LFDD schemes in the best case are not even triggered and no critical demand would be disconnected.



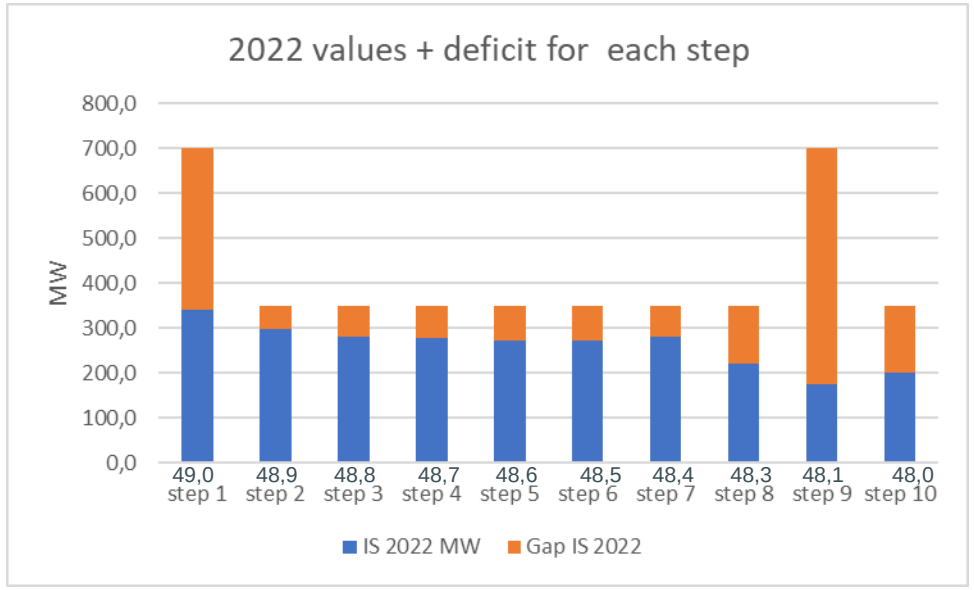
Gap analysis for each step based on monitoring 2022

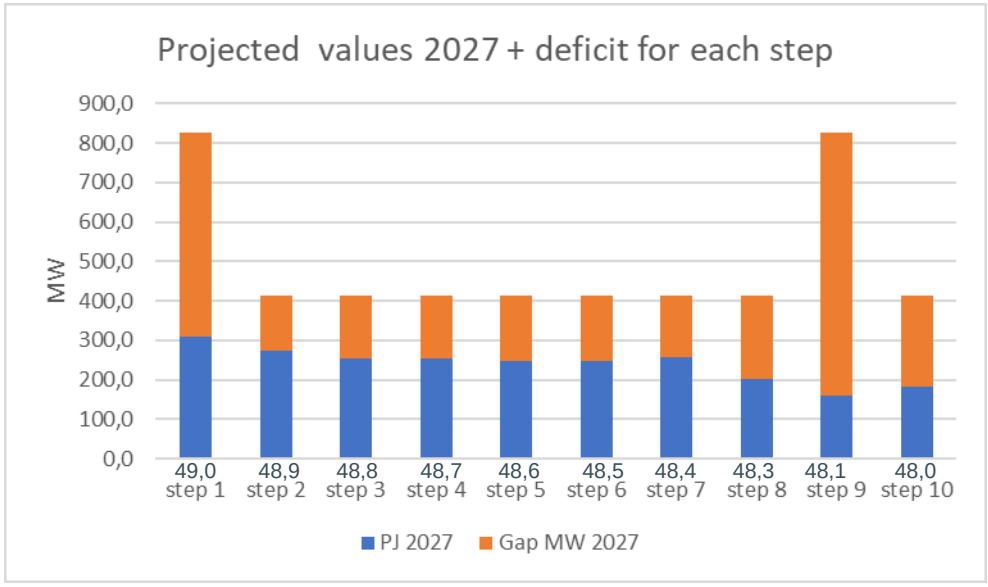




LFDD plan: target and gap in 2027

The actual LFDD plan (blue bars in left figures) will further decay to from 2.6 GW in 2022 to 2.4 GW in 2027. In DSO grids, more electrification will be over-compensated by more RES





By 2027 the LFDD plan should include 5 GW (= 45% of 11 GW). Conclusion: **2600 MW additional volume** must be included in the LFDD plan by 2027

Elia proposed multiple actions in parallel to increase the LFDD volume

- Add remaining substations in rural and urban areas (DSO grids) except from large city centers.
- Accelerate **selective load shedding** with flow sense detection and **blocking of reverse flows** in DSO grids.
- Remove rural substations with dominant **reverse flow**
- Add **industrial** load
- Call for reasonable LFDD targets in **EU legislation** and make use of **new technologies** to minimize LFDD action

Elia's objective is to comply with the EU Netcode with minimum societal and economic impact

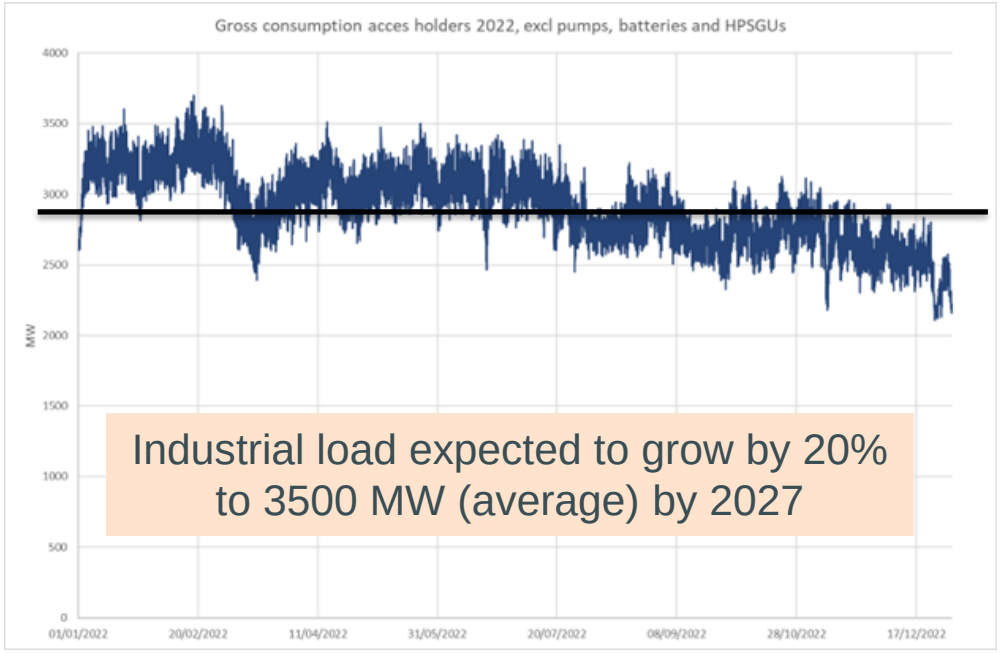
Demand facilities and closed distribution systems in steps 8 & 9

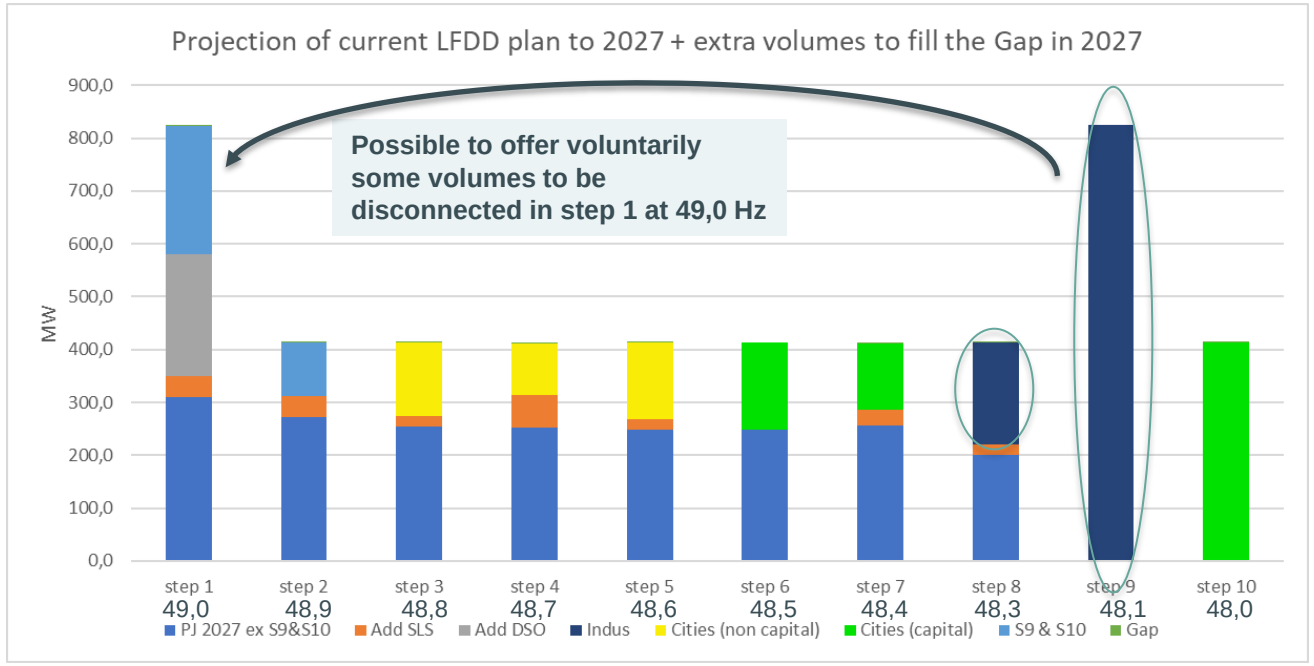
Equal burden sharing between 2 new entities: cities and industry

Remaining gap: **1017 MW**: 192 MW in step 8 and 825 MW in step 9

Load profile industry (2022)

Avg= 2914 MW





Nuclear sites, Fluxys and Infrabel are excluded from load shedding

30% of gross consumption must be interruptible in 2 steps:

6% in step 8 and 24% in step 9 + possible to pass obligation to another grid user.

LFDD Groups are allowed

		Gross cons (MW)	30% of Gross cons (MW)		step 8	step 9
	frequency Hz				48,3	48,1
	allocation per step				6%	24%
Individual disconnection	GU1	185	56		11	44
	GU5	150	45		9	36
	GU4 (part of CDS 1)	160	48		10	38
	CDS 2	85	26		5	20
LFDD group 1	GU2	125				
	GU3 (part of CDS 1)	200				45
	GU6	125			100	
	GU7	300			35	45
	Total Group 1	750	225		45	180
LFDD group 2	GU8	240			100	
	GU9 (part of CDS 1)	250			85	
	GU10	240				
	GU11	300				124
	Total Group 2	1030	309		62	247
	Total all GU	2360	708		142	566

- LFDD grouping allows different grid users to cluster their LFDD obligations
- This allows individual industrial grid users to pass their LFDD obligation fully or partially to one or more other industrial grid users.
- The precise number of f-cubicles to be installed is still uncertain and depends on LFDD groups composition
- **Each individual grid user informs Elia by 30/06/2024 about**:
  - Implementation as individual or group member
  - Contribution to LFDD group (% and steps)

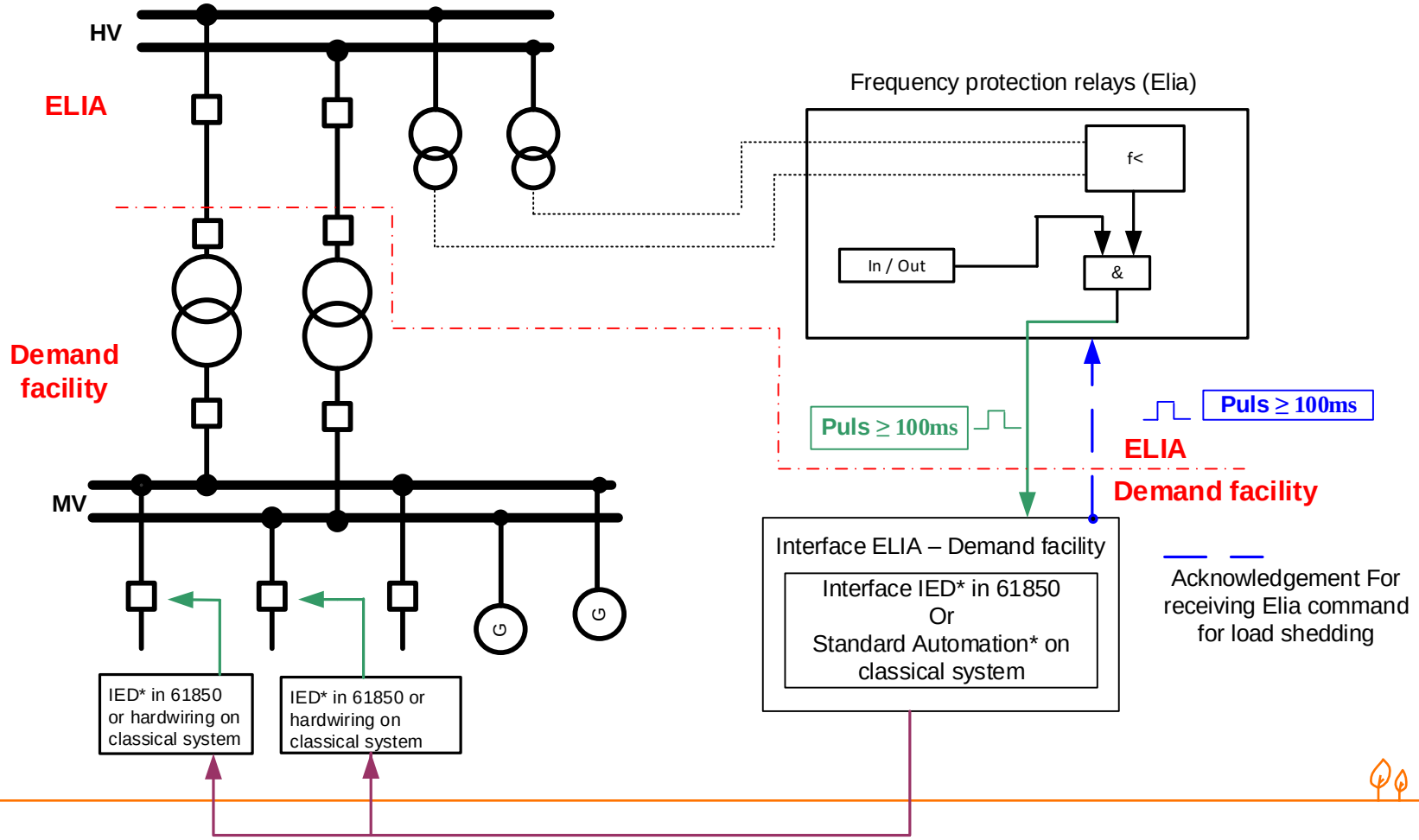
An annex including the individual contributions of the corresponding LFDD group members, signed by all group members and Elia, will be added to the **connection agreement** of the individual group members → this is subject to later approval of the connection agreement

Technical concept

Practical implementation in industry

NC ER art 15(6): Elia should install the frequency relays

6. Each TSO or DSO shall install the relays necessary for low frequency demand disconnection taking into account at least load behaviour and dispersed generation.



- Standard: Elia will install own and maintain the frequency relays and signals up to the interface cubicle
- Trip signals passed from Elia to interface cubicle
- Demand facility picks-up trip signals and sends them to selected demand interrupters
- Customer is free to choose the best way of implementing the load shedding from the interface cubicle (hardwired, IEC61850, …) to its MV breakers

Total tripping time

- Relay requirements in the new (draft updated) European Network code for Demand Connection (art 19.1c)

(c) the low frequency demand disconnection functional capabilities shall allow for operation from an electrical input signal to be specified by the relevant system operator, in coordination with the relevant TSO, and shall meet the following requirements:

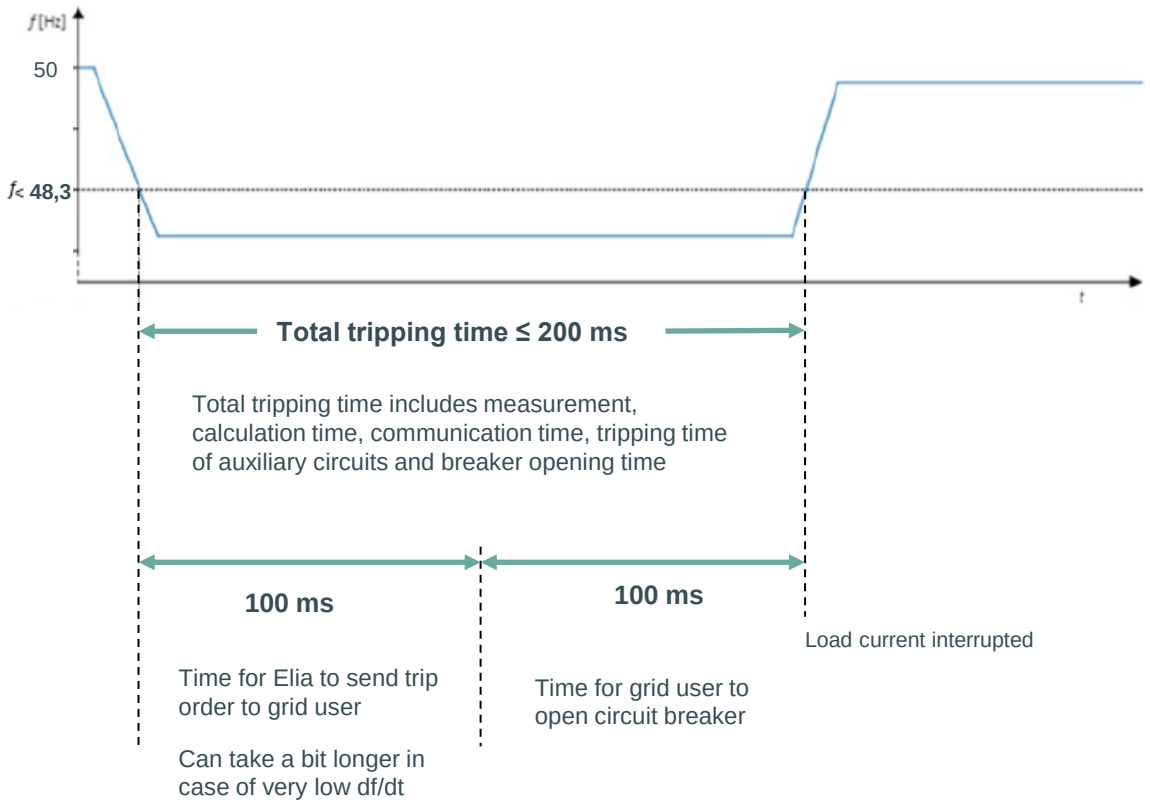
(i) frequency range: at least between 47-50 Hz, adjustable in steps of 0,05 Hz;

(ii) maximum total tripping time: no more than 200 ms, starting from the system frequency crossing the frequency setpoint to the circuit breaker opening, including all necessary relay operating times, such as measurement and calculation time and tripping time of auxiliary circuits;

(iii) relay accuracy: lower than 30 mHz;

(iv) voltage lock-out: blocking of the functional capability shall be possible when the voltage is within a range of 30 to 90 % of reference 1 pu voltage;

(v) provide the direction of active power flow at the point of disconnection;



- New Network code DCC is now following approval trajectory in the European Union
- It is expected to enter into force in 2025

Roll-out of frequency relays

- Grid users will be contacted by Elia two years before the planned due date.
- Elia plans to commission the frequency cubicle and link to the grid user before the due date.
- Grid users will have to prepare local demand disconnection equipment from the interface cubicle to the circuit breaker(s) contact on their site, so that the whole chain can be tested and commissioned on the due date.

Test to be included in test plan (later this year)

- Site acceptance test (SAT) during commissioning
- Periodic test every 10 years
- Elia aims to do an end-to-end test as much as possible. However, it is not possible to test all elements of the chain (opening of the CB for example). In this case we add the time of the not tested elements based on the datasheets.
- After completing the SAT test, Elia and the grid user sign a document together engaging them that the implemented solution respects the requirements, including reaction times.

Frequently asked questions

Q&A during the NL & FR sessions of 25/1/2024 are included

Frequently asked questions

1) What is the real required consumption reduction in case of LFDD activation ? 30% of the site nominal, average or **instantaneous consumption ?**

The demand to be disconnected is 30% of the **gross instantaneous consumption**, at the moment of a frequency collapse in the electricity system.

2) How is **gross instantaneous consumption** correctly defined?

Gross Instantaneous Consumption = [electricity consumption in MWh of all Installations at the grid user's site during the quarter-hour prior to the quarter-hour in which the LFDD obligation is to be performed, minus the electricity consumption of storage units operating in charging mode and minus the electricity consumption of the auxiliaries of power generation modules or other facilities identified as significant high-priority grid users in Elia's System Defense Plan] / [0.25 h]

Frequently asked questions

3) How does Elia consider the 30% during **major Shutdowns & Turnarounds** where the industrial site requires only an essential baseload?

If a frequency collapse occurs during a SD & TAR, only 30% of the remaining instantaneous gross consumption must be interrupted.

4) During **major Shutdowns & Turnarounds**, can the grid user pass its obligation temporarily to another LFDD group member?

The grid users' LFDD obligation will be reduced during SD & TAR (see previous answer). Temporary transfer of LFDD obligations during TAR is to be avoided for administrative simplification.

5) What if the immediate shutdown command of 6% (or even 30%) leads to the **complete shutdown of the process** resulting in a decrease of 100% power? E.g. 100 MW (= 90MW process + 10MW motive power) --> 30% shutdown should lead to 100MW→ 70 MW but will in practice lead to 100MW → 10MW (90MW trip completely due to nature of the shutdown). **Is this a problem** ?

Over-reaction should be avoided. However, in such case Elia recommends to make the "excessive volumes" available to other grid users via an LFDD group.

Frequently asked questions

6) Should grid users determine what the **net offtake** is with renewable generation with **solar and wind** or without? The power to be switched off will be very volatile. How should grid users deal with that?

The net offtake is not used as a reference to determine the volume of demand to be disconnected !

The netted demand to be disconnected by the grid user is 30% of its **gross consumption**.

Disconnection of solar, wind or other local production units (CHP) should be avoided as much as possible .

The grid user should disconnect preferably only electrical consumer devices such as e.g. electrical heating, lighting, electric motors driving conveyors, pumps, ventilators, compressors, …

7) If you **don't take anything net from the grid**, will there be any signal to switch off?

Yes, there will be a signal to switch off to disconnect 30% of the gross consumption, independent from the net offtake from the grid !

Frequently asked questions

8) How is the "**gross instantaneous consumption**" value based on quarter-hourly data determined? Grid users' own on-site measurements are not going to produce the exact same number as Elia's. Measurement errors and measurement time intervals may vary slightly.

The grid user has access to the measurements registered by Elia on the connection point. Considering local production measurements allows the grid user to determine its gross instantaneous consumption.

9) Is an 'official' quarter-hourly consumption value given with the order to switch off, from which the consumer can **derive the exact amount of power to be switched off**??

No, Elia will only send a pulse signal when the frequency drops under a certain limit (e.g. 48.3 Hz). The demand facilities to be disconnected are to be determined ex-ante by the grid user so that 6% and 24% can be approached as good as possible.

10) In case of **multiple site connections**, is the 6% and 24% to be fulfilled per connection or per site?

The 6% and 24% obligation refers to the instantaneous gross consumption of the grid user and is independent from the number of connection points.

Frequently asked questions

11) What is the **time duration** of a possible load disconnection event ?

The expected time duration is between 15 minutes and 30 minutes.

After an event that triggered an LFDD activation which did not lead to a total system collapse, Elia's operators will perform a safety check together with the "frequency leader" of the European grid.

As soon as the system is considered sufficiently stabilized, Elia will contact the individual grid users by phone, to give permission to restart their load that had been switched off.

Frequently asked questions

12) What becomes the consumption reduction if the site consumption is already limited (for instance in the frame of R3) at the time of the LFDD activation ? Is it expected that **R3 reserves** on sites will already have been activated when the LFDD plan would be triggered at freq = 48,3 Hz ?

Consumer facilities could already have reduced their demand due to mFRR activation (R3 demand reduction reserves) before the frequency collapse.

In such case, the grid user should be able to reduce 6% and 24% of the remaining gross instantaneous consumption, if the frequency collapses below the respective thresholds.

Example: a grid user consumes 110 MW of which 100 MW is offered as mFRR demand reserves.

On day D, Elia activated the 100 MW mFRR. The remaining gross consumption is 10 MW. The grid user should be able to disconnect 3 MW if the frequency drops below the threshold values.

During periods when no mFRR is activated, the grid user should be able to disconnect 33 MW (30% of 110 MW)

Frequently asked questions

13) At times of low grid frequency, are **electrolysis** processes allowed to go to minimal power use ?

In the new draft European demand connection code, “new” electrolysis process are supposed to start reducing their consumption with decreasing frequency between 49.80 Hz and 49.0 Hz. This means before the LFDD plan is activated.

14) BESS (batteries) probably inject during moments of scarcity because of interesting market prices. Do batteries that support the grid always count for LFDD if they also help support the grid?

Batteries in charge mode should reduce their power consumption as soon as the frequency drops below 49.80 Hz. If the frequency has dropped to 49.0 Hz, then the battery should have reduced its power consumption to zero.

Batteries in injection mode should increase injection with decreasing frequency (up to maximum power)

This means that battery consumption reduction should not be counted for the LFDD requirement, but battery consumption should also not be counted for the grid user's gross consumption.

Frequently asked questions

15) How the LFDD plan applies to **CDS** ? What is the obligation and what are the expectations for both the CDSO and/or present grid users with regards to load reduction ?

We prefer that the CDS, which has a connection agreement with Elia, fulfills the LFDD obligation as one entity. The CDSO could agree internally with individual CDS grid users about which consumer installations should be disconnected.

Frequently asked questions

16) The implementation of the LFDD plan will require some relays installation/upgrades. Who will support the **related costs** ?

de relais voor de frequentiemetingen en de beslissing om uit te schakelen zullen aangekocht en geïnstalleerd door Elia

The relays to measure the frequency and the control logic to generate the trip orders will be purchased and installed by Elia. The trip orders will be passed to the grid user through the interface cubicle.

The grid user distributes the trip orders to the individual consumer installations that should be disconnected. These related costs have to be born by the grid user.

17) Is a **renumeration** provided for this disconnection?

No. Low frequency disconnection is an emergency measure from the system defense plan for which no remuneration is provided, neither to grid users connected to the distribution grid nor to grid users connected to the transmission grid.

Frequently asked questions

18) What are the **fines or consequences** if a grid user can't comply with these regulations? Are there any exceptions?

If an actual frequency collapse cannot be stopped and this would lead to a blackout because too little would have been disconnected, then it will be verified who has disconnected less than their legally required net consumption.

Parties who are disadvantaged could make claims to those who have not disconnected enough.

19) Elia will contact the grid user **2 years in advance** with regard to which time reference point?

Elia will send a letter to the grid user on date DD/MM in year Y, to announce that the LFDD installation should be ready to do an end-to-end commissioning test on date DD/MM in year Y+2

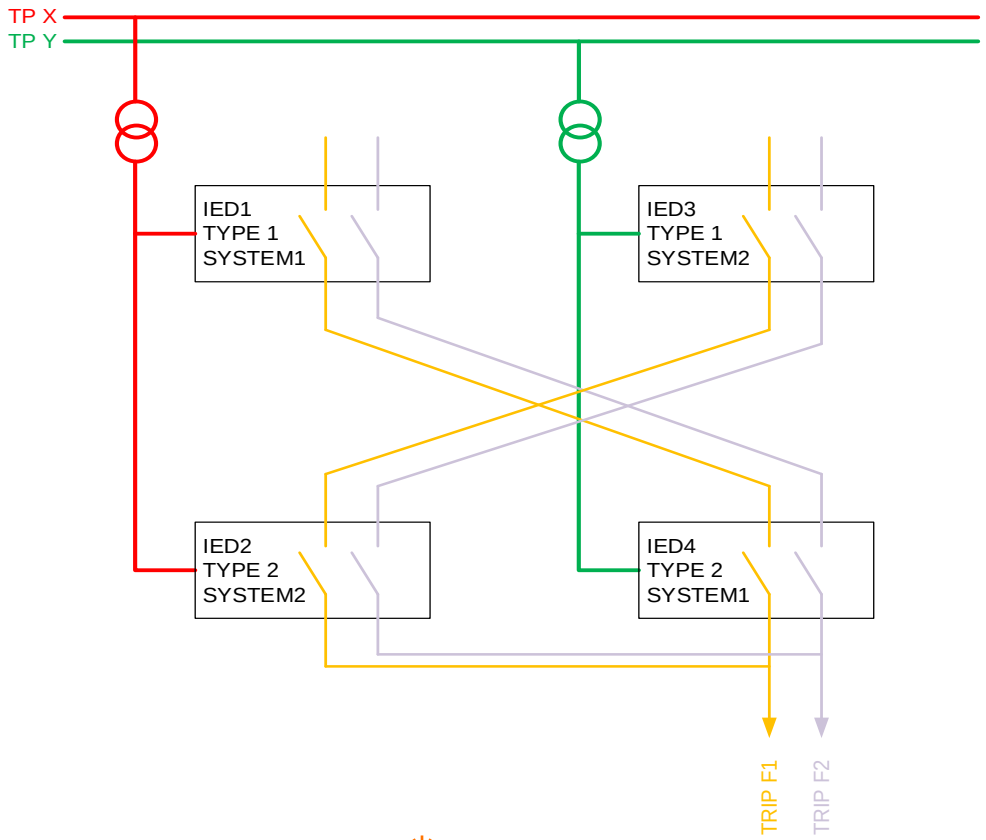
Frequently asked questions

20) What **precautions** will be taken in order to avoid the LFDD relays operate in case of incidental frequency decrease not linked to a grid balance default ? (short circuit situations, grid incidents...)

Elia will apply the same concept as currently used for disconnecting load in public distribution systems.

Two independent voltage measuring transformers are used. Each of them serves as input to two different types of frequency relays that calculate the frequency of the voltage waveform and compares this with the pre-defined frequency threshold. Both ways need to draw the same conclusion before giving the trip order.

The relays are blocked in case of low voltage (short circuit), to avoid unwanted trips.



Frequently asked questions

21) Does Elia expect frequency drops to 49Hz in 2026 ? What does Elia think are the **causes of** that?

A frequency drop is a result of a totally unexpected (major) incident. We make every effort to avoid it but cannot completely rule out the possibility that it could ever happen.

The last major frequency drop to 49 Hz dates back to 2006 and resulted from an unexpected splitting of the European power grid into several parts.

22) Will the arrival of the additional wind turbines in the North Sea and by extension in Europe create **more fluctuations in the grid**, resulting in possible LFDD activations?

Frequency volatility may increase due to the decrease in "rotational inertia" in the European grid and the continuous increase of fluctuating renewable energy sources.

Elia plans installing synchronous condensers and imposing “synthetic inertia” capabilities in “grid forming” inverter-based resources to avoid too much frequency fluctuations.

Frequently asked questions

23) What are the expectations regarding **probability and duration of situations with 49.0 Hz** (are these based on modeling/simulations?)?

The last time f=49.0 Hz in Belgium was in 2006. Second last time in 1982. f<49.8 Hz only once in last 5y

In the frequency range between 49.80 Hz and 49.00Hz, Europe-wide automatic actions are started such as:

- Pump stations operating in pump mode are automatically shut down
- Voltage in distribution networks is reduced by 5% to temporarily reduce consumption
- The batteries (+EV, P2G, HP) reduce their charge mode according to the decreasing frequency.
- All rotating reserves on production units are released according to the declining frequency.

If this is not sufficient and frequency drops further to 49.0 Hz, the LFDD is activated to avoid a total collapse.

The probability of frequencies below 49 Hz is extremely low.

Frequently asked questions

24) Will this disconnection be automated with **frequency controlled relays** or is this a **manual** shutdown?

This is about automated disconnection based on frequency relays.

Elia provides the frequency relays and transmits the shutdown order to the grid user, who in turn transmits it to the switch(s) that interrupt consumption.

The time between falling below the frequency threshold and interrupting consumption should not exceed 0.2 seconds by law.

25) Is participation on a **voluntary** basis or will this become **mandatory** after the approval by the minister? LFDD participation is mandatory: 30% of gross instantaneous consumption should be prepared for disconnection either in two steps (6% at 48,3Hz and 24% at 48,1Hz) or in 1 step (48,3 Hz or 48,1Hz to be decided by Elia).

The grid user is free to disconnect a volume between 0% and 30% at 49,0 Hz on voluntary basis.

Frequently asked questions

26) We are a **Seveso company** and absolutely cannot shut down parts of the plant. We do **not** see this **obligation** as **feasible** within our company without compromising safety.

No exception is provided for Seveso companies.

LFDD grouping allows transferring the obligation to other grid users. The group members can share the net consumption to be disconnected (30% of the group's gross consumption) by mutual agreement.

Elia understands the concerns. Elia's primary goal is to **immediately stop a sudden frequency collapse** and avoid a blackout. We do this by providing sufficient net demand disconnection power, as defined at European level.

Interruption times are much more limited compared to a grid restoration after a blackout. Although the optimal economic conditions cannot be maintained, in this way we avoid worse.

With the 30% rule, Elia treats all transmission-connected consumption facilities in a non-discriminatory manner.

Frequently asked questions

27) May an **LFDD group** also be formed with another company without any other link at all ? Yes

28) Is Elia not going to install frequency relays on sites that are not participating themselves, but who are part of an LFDD group ? Correct !

29) How could any LFDD grouping proceed practically? Through bilateral or multilateral contacts between individual grid users

30) Why is Elia not bringing grid users into contact with each other to form LFDD Groups? Elia wants to remain independent and neutral towards each grid user.

31) Could the “Febeliec” federation perhaps facilitate this ? This might be a good idea.

32) Is there a **price** set **per interruptible MW** that or is such price to be agreed on between parties?

Elia does not specify a price per interruptible MW.

Elia does not intervene in price-agreements between parties that want to cluster their LFDD obligations

Frequently asked questions

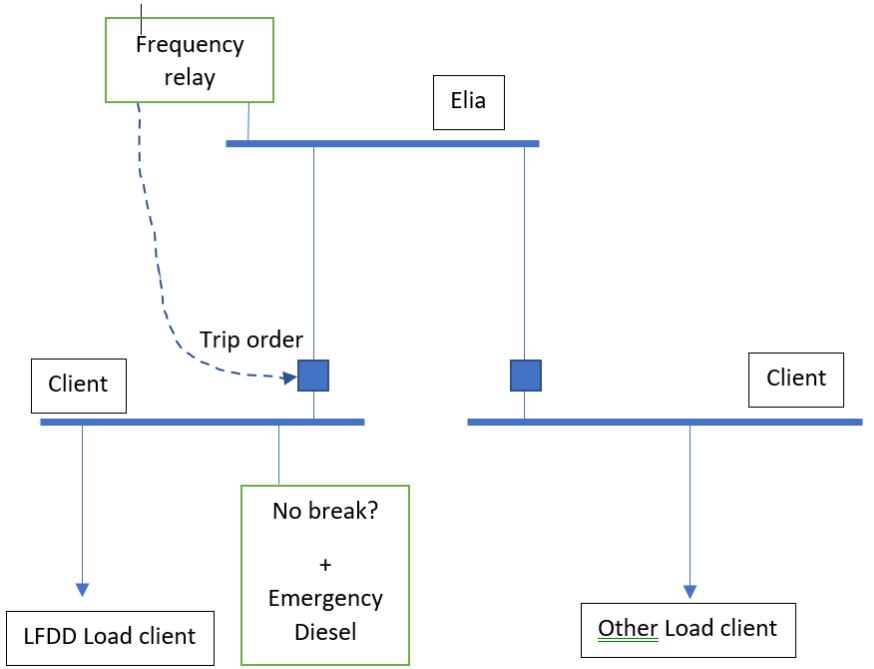
33) Do emergency generators or batteries also count as switching off or reducing power?

Local generation such as a CHP, a PV farm, a local diesel or battery ... should not be switched off during a frequency dip. Only consumption should be switched off.

It is necessary to disconnected 30% of the gross load from the grid within 0.2 seconds, which implies the use of a fast circuit breaker between the grid and the load.

A drop in frequency always happens unexpectedly, without warning.

Generators take longer to start up. So if the customer wants to avoid an interruption at all costs, he needs no-breaks (=batteries) of the same size as the load to be disconnected.



Frequently asked questions

34) Are there provisions regarding ev. **priority return to service** when 49Hz situation stabilizes again?

Hospitals that were disconnected in distribution networks will be given the highest priority in returning to service.

Elia grid users who voluntarily offer interruptible power at 49,0 Hz could also be returned to service very early in the process. We have yet to discuss this with the public authorities.

35) To which step are voluntary interruptible volumes at 49,0Hz **deducted** from (1st 6% or 2nd 24%)?

Voluntarily disconnect volumes at 49.0 Hz are first deducted from the 6% obligation at 48.3 Hz. The portion above 6% is deducted from the 24% obligation at 48.1 Hz

Contractual framework

Two new annexes about LFDD in the connection agreement (publicly consulted until 16/2/2024 **(subject to later approval of connection agreement)**

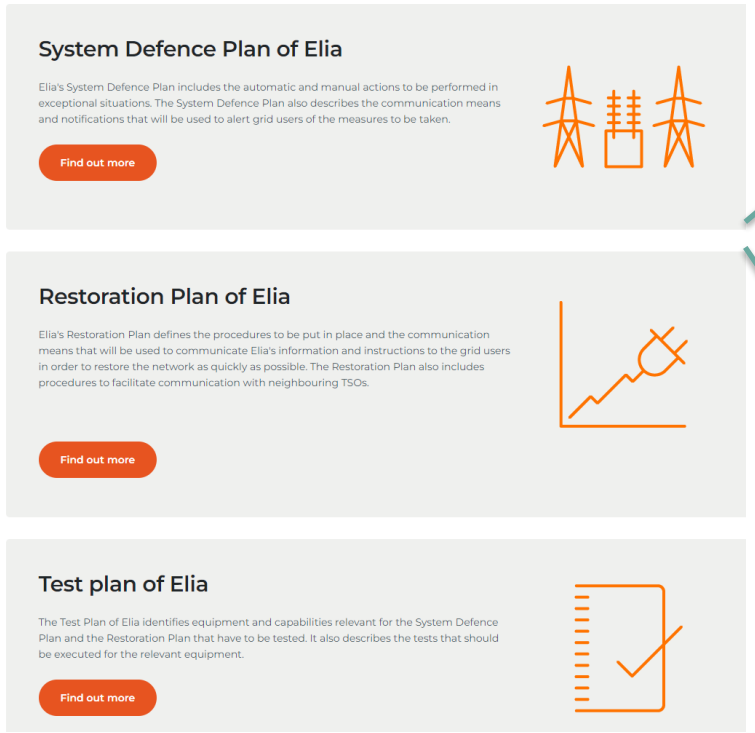
- Annex 11:
  - Individual or via LFDD group → to be specified **via EPIC or via mail** by 30/6/2024
  - Disconnect obligatory volume in either 2 steps 6% at 48,3 Hz and 24% at 48,1 Hz or in 1 step 48,3 or 48,1 Hz to be decided by Elia → **via EPIC or via mail** by 30/6/2024
  - Voluntary volume disconnected at 49,0 Hz (cfr mailing 16/11/23)
  - Summary: % to be disconnected at 49 Hz; 48,3Hz and 48,1 Hz

- Annex 11 bis
  - Specification of LFDD group
  - Contributions of each group member
  - If one member steps out, the other members update this annex

	Mede-contractant	Netgebruiker [A]	Netgebruiker [B]	…	Netgebruiker [X]
Procentuele bijdrage van elk lid van de LFDD-Groep bij een frequentie = 49.0 Hz (schijf 1).					
Procentuele bijdrage van elk lid van de LFDD-Groep bij een frequentie = 48.3 Hz (schijf 8).					
Procentuele bijdrage van elk lid van de LFDD-Groep bij een frequentie = 48.1 Hz (schijf 9).					

Next steps

LFDD documentation on Elia website



Low Frequency Demand Disconnection Plan

Implementation guidelines for transmission connected demand facilities and CDS

Find out more

Expected soon

- This presentation
- Technical concept note
- LFDD design note
- Further guidelines

Timeline

April 2024:	Announcement by Elia to enter LFDD choices in EPIC
March – June 2024	Specification of the Test Plan
June 30th 2024:	Deadline to make choices in EPIC (or via mail)
In course of 2024	Elia will communicate “due date” to grid users
2024 – 2026	Preparation period
2026 ↓ 2029	Roll – out and commissioning of frequency cubicles

Thank you.