Flexibility Framework

International Experiences for Colombia's Challenges

Diego Tejada
Technical Leader

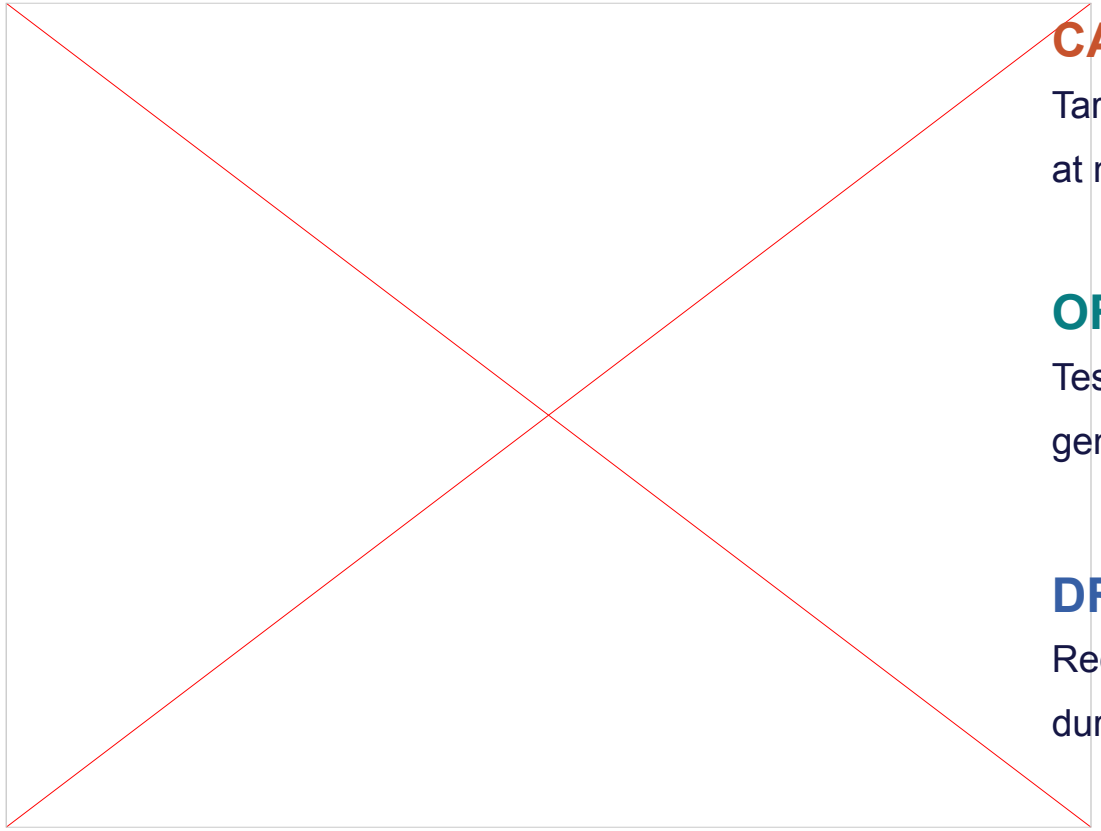
October 2026
Congreso de Energía MEM

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Colombia's Challenges

Demand flexibility could help manage regional constraints and dry-period supply stress

Potential applications of flexibility



CARIBE · CONSTRAINED LOCATIONS

Target demand reduction

at network bottlenecks

ORIENTAL · VOLTAGE SECURITY

Test demand reduction where local

generation supports secure operation

DRY PERIODS · ENERGY AVAILABILITY

Reduce net grid demand

during supply stress

The next step is to define where, when and for how long loads can respond

Administrative shading locates the regions; it does not define XM operating areas or congestion boundaries.

Sources: XM annual operating report 2025; Map: Natural Earth

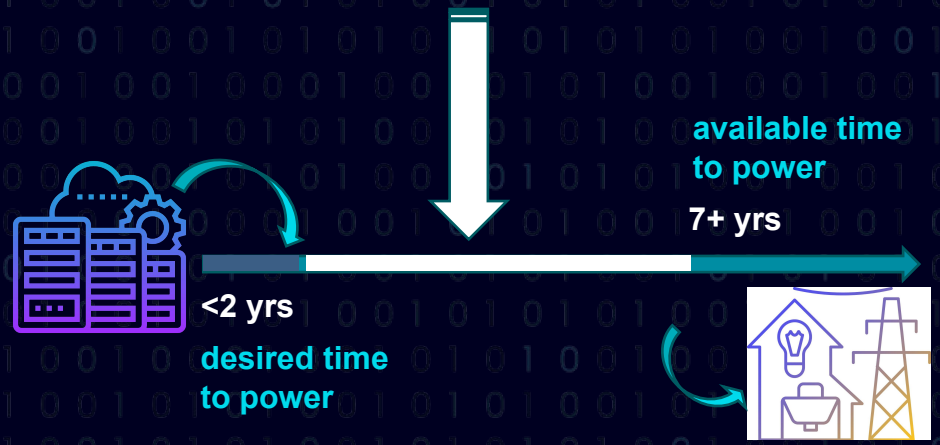
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Flex MOSAIC™

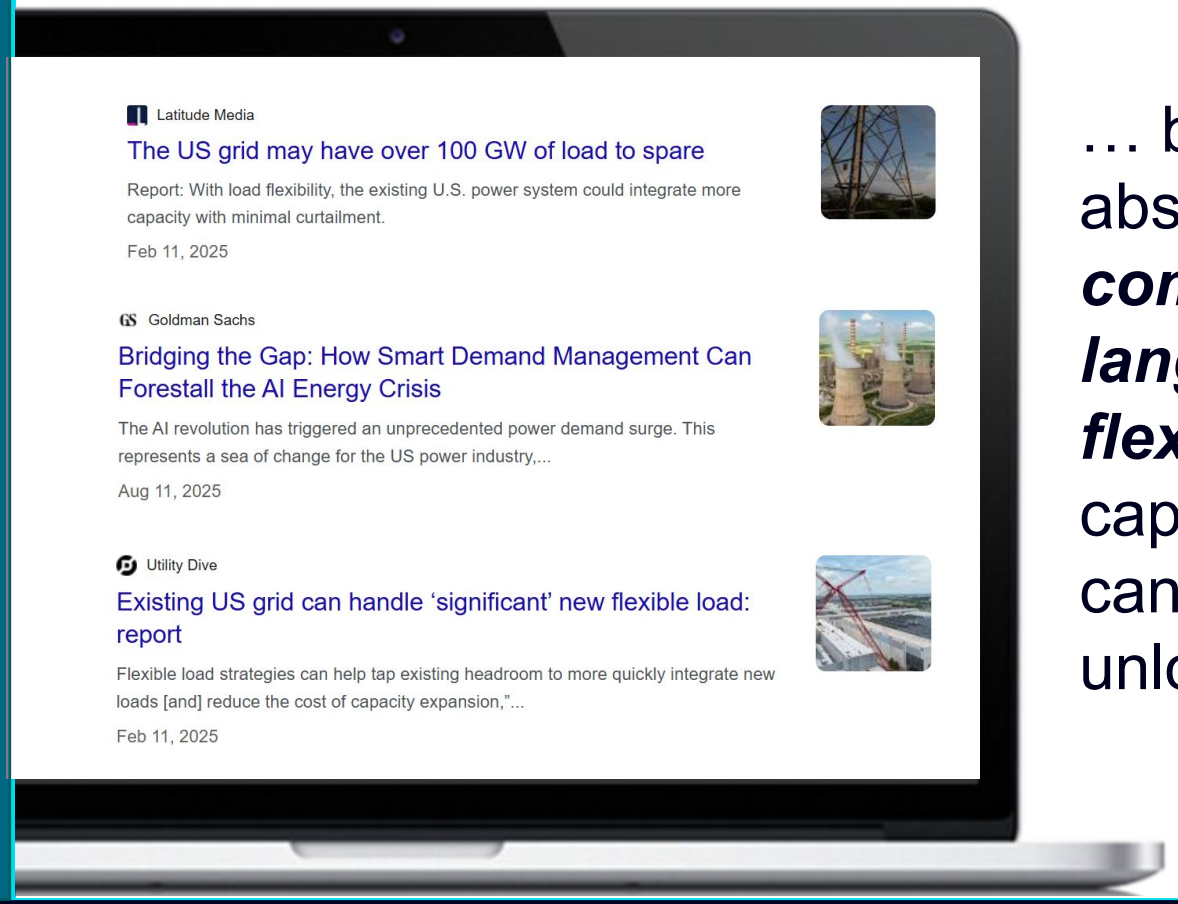

FLEX
MOSAIC

Powering Large Loads

CHALLENGE
gap between load & grid need & capacity availability



SOLUTION
Grid-integrated Flexible Load



… but in the absence of *a* ***common language on flexibility*** grid capacity cannot be unlocked

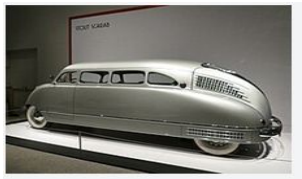
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Standardization makes complex industries work

Without a shared standard, every design was a different



Dymaxion
1933
Three wheels, rear steering



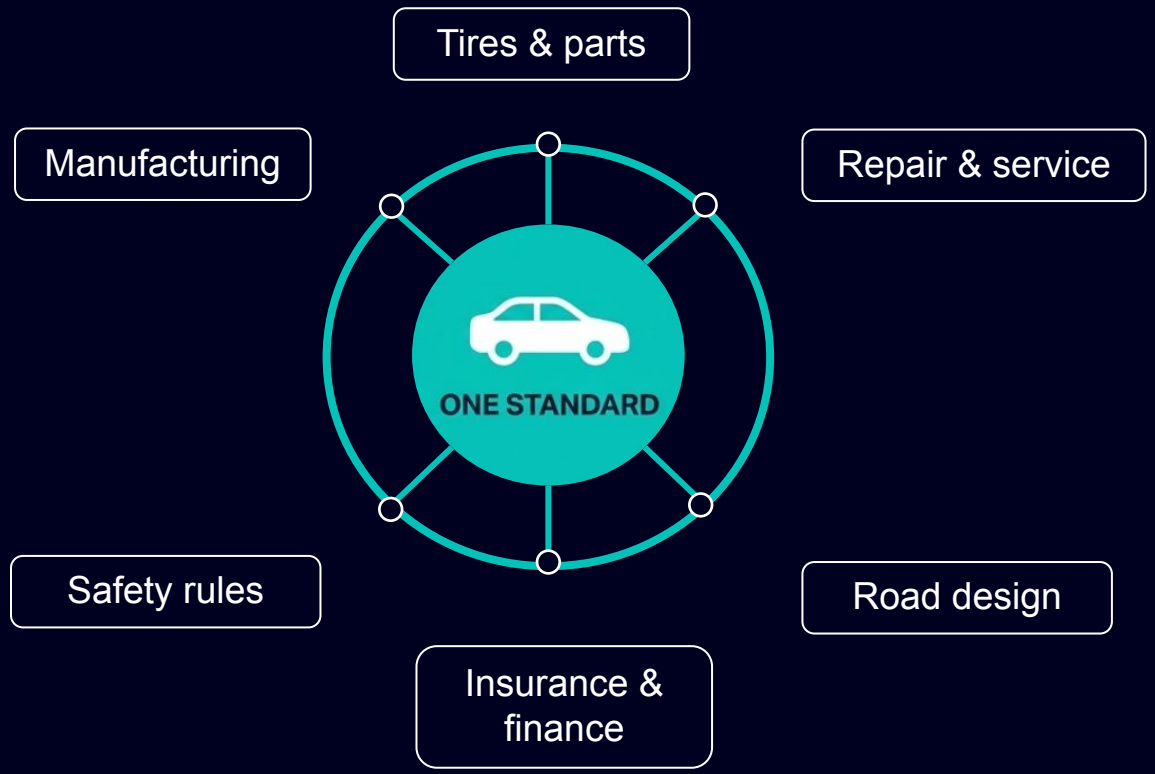
Stout Scarab
1935
Lounge-style interior



Peel P50
1962
One seat, three wheels

STANDARDIZE

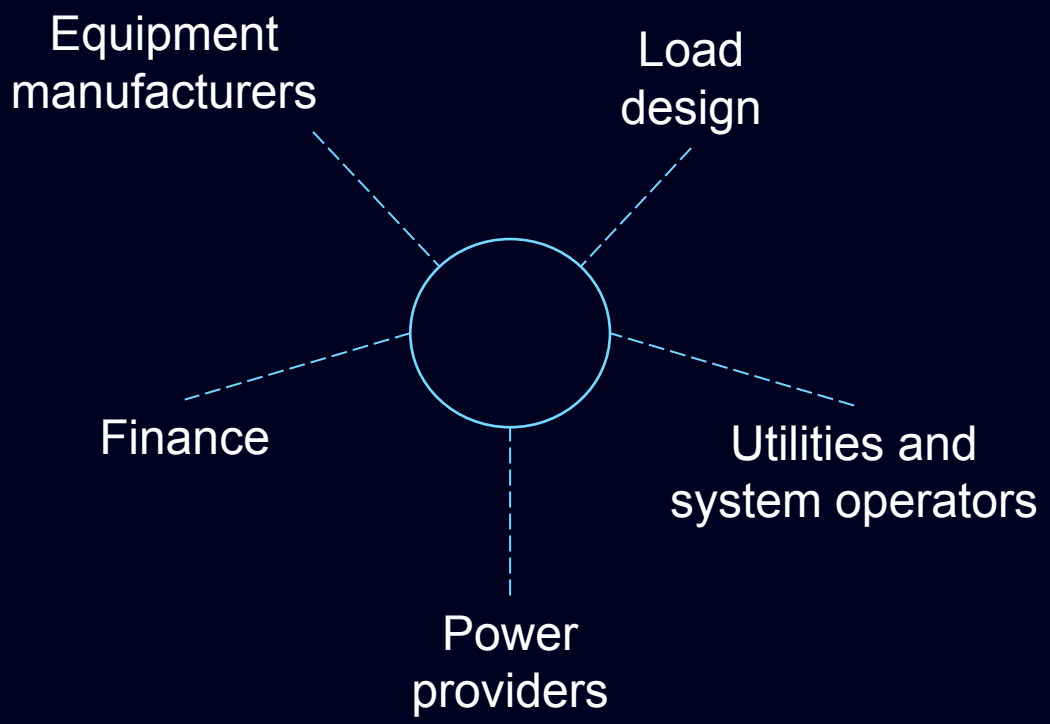
With a shared standard, one shared definition unlocks an entire ecosystem



Flex MOSAIC™ establishes a shared language for large load flexibility

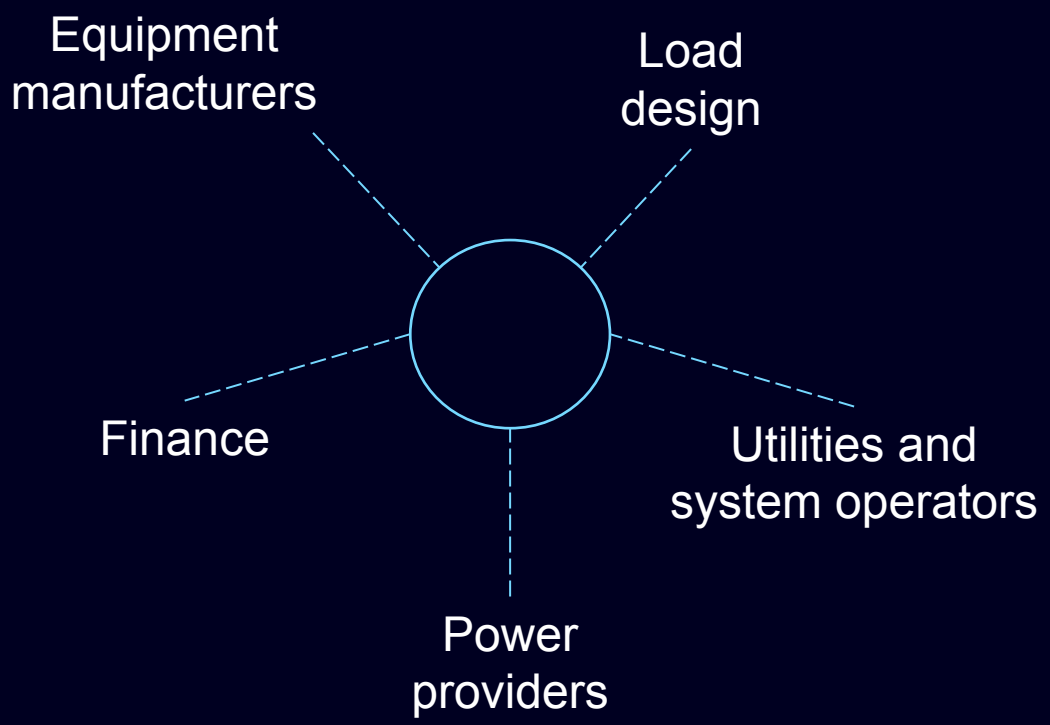
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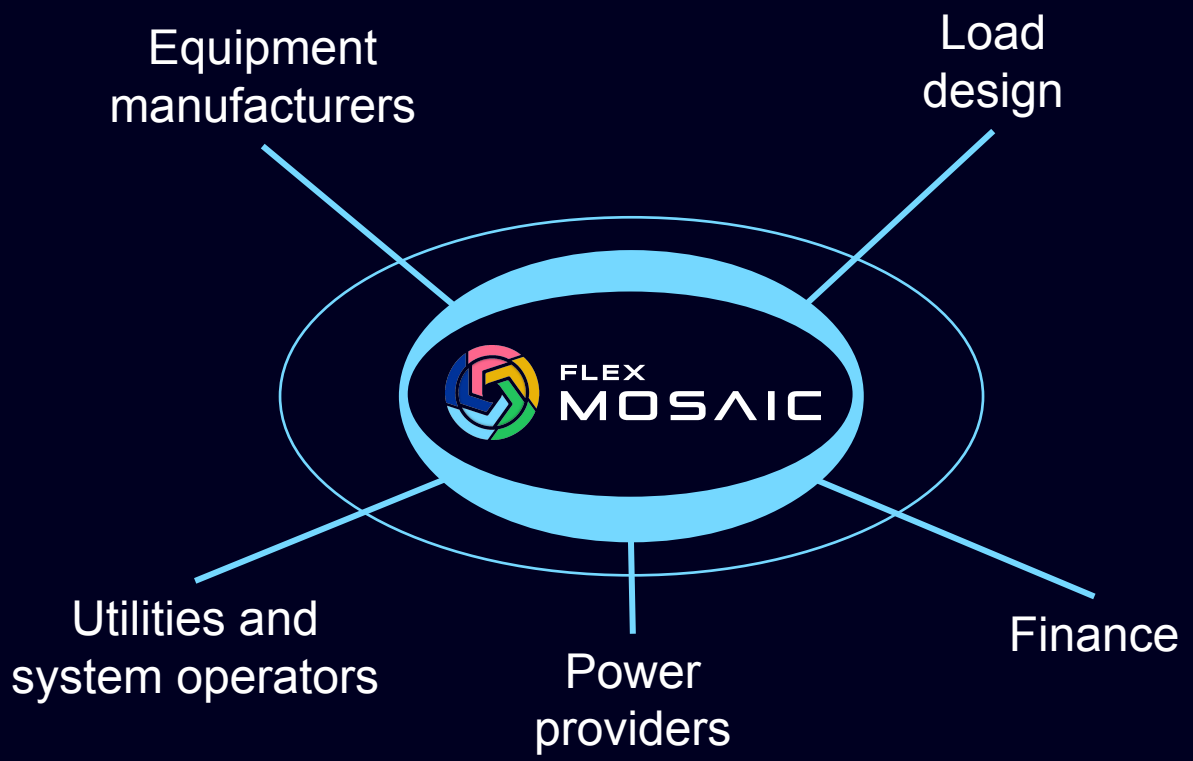
Large load flexibility has been stuck in the bespoke era



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Large load flexibility has been stuck in the bespoke era





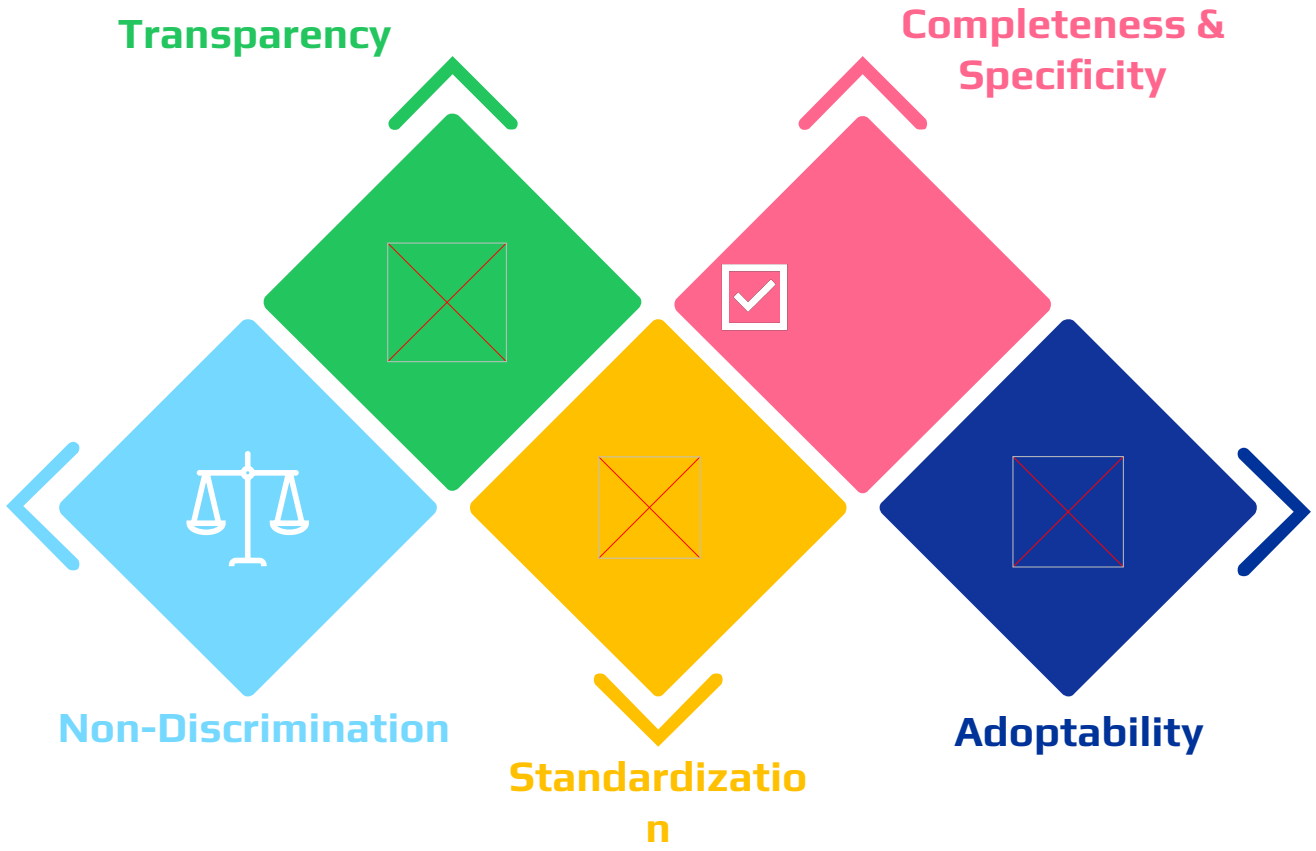
Flex MOSAIC™ establishes a shared language for large load flexibility

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Framework Purpose & Guiding Principles

Create a common language for load flexibility

Accelerate speed to power while maintaining reliability



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Flexibility

A Common Flexibility Classification to unlock grid capacity without compromising reliability and affordability

FLEX MOSAIC

INCREASING FLEXIBILITY

CLASS A	CLASS B	CLASS C	CLASS D	CLASS E
Critical Peaking	Peaking	Prolonged	Fast	Fully Grid Responsive
Hours to day-ahead	Hours to day-ahead	Day Ahead	≥ 5 min	≥ 5 min
≤ 5 Hours	≤ 5 Hours	24+ Hours	≤ 5 Hours	Unbounded
≤ 1%	2 – 10%	≤ 10%	2 – 10%	Unbounded

Notification Window

Activation Period

Annual Utilization

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Broad Cross-Sector Support

Reliability & Standards Authorities

NERC

Financial & Advisory

AURUM

ELECTRIC POWER ENGINEERS

ING

KPMG

PACES

Grid & Market Operators

California ISO

CENACE CENTRO NACIONAL DE CONTROL DE ENERGÍA

ieso Connecting Today. Powering Tomorrow.

smart KPX

MISO

SPP Southwest Power Pool

Electric Utilities & Public Power

Alliant Energy

aps

Constellation

DTE

energeia

entergy

exelon

Georgia Transmission

LPPC LARGE PUBLIC POWER COUNCIL

LES

LCRA ENERGY • WATER • COMMUNITY SERVICES

nationalgrid

Nebraska Public Power District Always there when you need us

NEW YORK STATE OF OPPORTUNITY. NY Power Authority

octopus energy

PNUCC

PGE

ppl

PSEG

REC RayburnElectric COOPERATIVE

RWE

SKP

Southern Company

UNITED POWER Your Touchstone Energy® Cooperative

Technology, Data Centers, & OEM's

Algo-Energy™

COMPASS datacenters

CAMUS

Carrier

CAT

ERock

Google

Honeywell

JENBACHER INNIO

PADO

L&D

Meta

MITSUBISHI ELECTRIC

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.

nel

NVIDIA

pebble

SIEMENS

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Flex MOSAIC™
International Examples

FLEX MOSAIC

Notification Window
Activation Period
Annual Utilization

CLASS A

Critical Peaking

Hours to day-ahead
≤ 5 hours

≤ 1%

COMMON NAMES

- Emergency Demand Response, Reliability Demand Response
- Some Capacity Market Obligations
- Resource

EXAMPLES

Demand Response Power Flex Program | TVA

US Utility Demand Response Program for Capacity and Emergency,

Existing Facilities >1MW with a 500 kW annual average on-peak interruptible demand

Notification time	Activation Period	Annual Utilization
12 hours for capacity, 60 minutes for emergency (multiple tiers and options)	2 – 4 hours for capacity No fixed duration for emergency	72 hours for capacity, option for 96+ hours, and custom contracting

Emergency Load Reduction Program (ELRP) | California IoUs (PG&E, SCE, SDG&E)

Notification time	Activation Period	Annual Utilization
Day-Ahead	1 – 5 hours	< 60 hours

Load Modifying Resource | MISO

US Market Program

Notification time	Activation Period	Annual Utilization
6 hours	4 hours	~64 hours 5 events in summer and winter, 3 events in spring and fall

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FLEX MOSAIC

Notification Window
Activation Period
Annual Utilization

CLASS A

Critical Peaking

- Hours to day-ahead
- ≤ 5 hours
- ≤ 1%

COMMON NAMES

- Emergency Demand Response, Reliability Demand Response
- Some Capacity Market Obligations
- Resource

EXAMPLES

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Emergency Load Reduction Progra
SDG&E)

(US Utility Demand Response for Emergency Re

Notification time	Acti
Day-Ahead	1 –

Load Modifying Resource | MISO

US Market Program

Notification time	Acti
6 hours	4 ho

SCE ELRP Event Notice: 5/1/2022 5 PM - 7 PM

SCE Emergency Load Reduction Program <email@elrp.sce.com>

An Emergency Load Reduction Program (ELRP) event has been scheduled. Your participation will help reduce grid stress during this grid emergency.

Event Date:	Sunday, May 1, 2022
Event Time:	5 PM - 7 PM

During this event, you are requested to reduce energy. A second notification will be sent if the event ends early.

Thank you for your participation and making an impact!

If you have any questions you may visit the Customer FAQ, email us at support@elrp.sce.com, or call us at 833-227-2580.

OPERATIONAL

System Condition	Trigger	Activation	Response	Recovery
System stress, actual or projected supply shortage	CAISO Flex Alert or EEA	Utility or DR provider notification	Curtailment (voluntary)	Resume normal consumption

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FLEX MOSAIC

Notification Window
Activation Period
Annual Utilization

CLASS B

Peaking

- Hours to day-ahead
- ≤ 5 hours
- 2 - 10%

COMMON NAMES

- Reliability Demand Response, Economic Demand Response
- Capacity Market Obligations
- Interruptible Rates
- Congestion

EXAMPLES

Connected Solutions Program | National Grid Massachusetts

US Utility Program, low-end utilization for class B, but higher concentration during season

Notification time	Activation Period	Annual Utilization
Day-ahead	2 – 3 hours	30-60 events per summer

Optional Interruptible Service Rider | Entergy Arkansas

US Utility Interruptible Rate

Notification time	Activation Period	Annual Utilization
7.5 hours	< 4 hours	580 hours

Capacity Steering Contract On Request | Grid Operators Platform for Congestion Solutions

Notification time	Activation Period	Annual Utilization
> Day-Ahead	Contract Dependent	Contract and Congestion Dependent

OPERATIONAL

System Condition	Trigger	Activation	Response	Recovery
Grid congestion	Congestion Situation	Operator sends a flex message	Modifying consumption or generation	Resume normal operation

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GOPACS matches local generation cuts with compensating flexibility elsewhere

CONGESTED LOCALITY

Rilland, Zeeland

Wind farm · Stedin

1.0 MWh

less generation

Local reduction addressed anticipated generation congestion.



COMPENSATING ADJUSTMENTS

Drenthe

Solar farm · Enexis

0.6 MWh less generation

Gelderland

Horticultural customer · Liander

1.6 MWh less consumption

Together: 1.6 MWh less generation and 1.6 MWh less consumption.

Event: TenneT, Netcongestie newsletter, March 2025 | Demand-side contracted capacity in 2025: 499 MW | Demand-side call activations: 47

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FLEX MOSAIC

- [x] Notification Window
- [x] Activation Period
- [x] Annual Utilization

CLASS D

Fast

- [x] ≥ 5 Minutes
- [x] ≤ 5 Hours
- [x] 2 - 10%

COMMON NAMES

- Real-time procurement of wholesale market products or services (Energy, Reserves)
- Curtailable or Interruptible Load Programs

EXAMPLES

Time of Use General Service Base Interruptible Program | Southern California Edison

US Utility Program

Notification time	Activation Period	Annual Utilization
15 or 30 minutes	Up to 6 hours	180 hours per year Year-round events, max 10 events per month

Large Industrial Consumers Demand Response (SRAD) | Red Eléctrica

EU Utility Program

Notification time	Activation Period	Annual Utilization
15 minutes	< 5 hours	Not bounded

Demand Response Resources or Programs | Common across ISOs/RTOs

US Wholesale Market Programs Providing Energy and Ancillary Services

ISO-NE Demand Resources, MISO Demand Response, NYISO Demand Response. Parameters below are based on market timelines and processes; dispatch setpoints are sent in real-time on a 5-minute basis and total activation and utilization amount dependent on market conditions

Notification time	Activation Period	Annual Utilization
> 5 minutes real-time and intraday processes	> 5 minutes, not bounded	Not bounded, limited in practice today

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FLEX MOSAIC

Notification Window
Activation Period
Annual Utilization

CLASS D

Fast

- ☒ ≥ 5 Minutes
- ☒ ≤ 5 Hours
- ☒ 2 – 10%

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OPERATIONAL

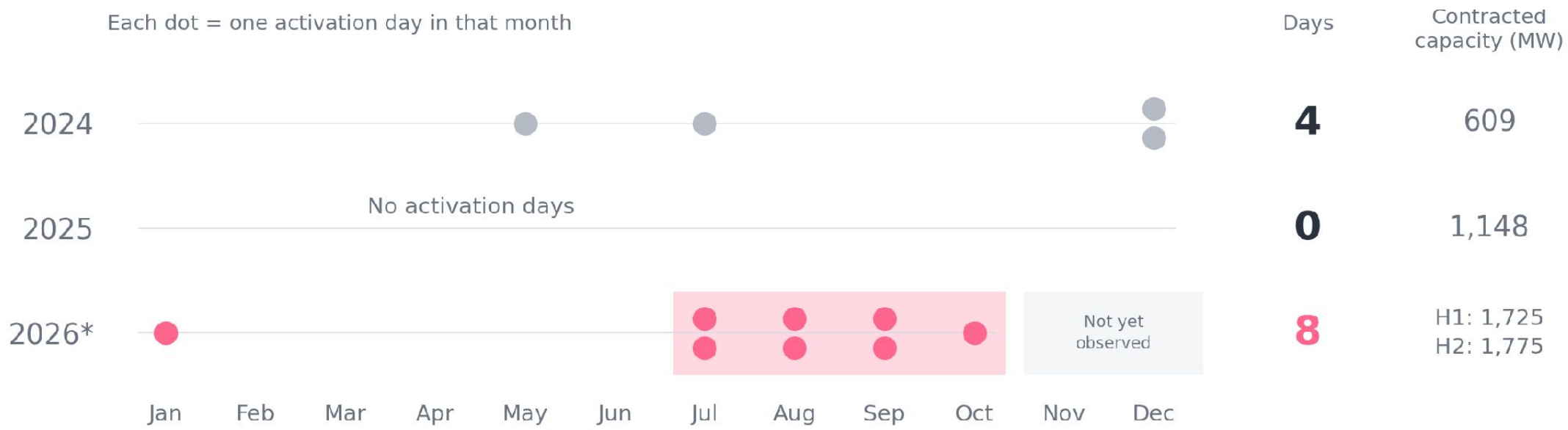
System Condition	Trigger	Activation	Response	Recovery
Insufficient upward balancing reserve	Utility determined capacity need	instructions via Generation and Demand Control Centres	Reduce consumption, maintaining delivery in the specified period	consumption resumes according to its planning

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FLEX MOSAIC

Spain is calling on demand flexibility more often to maintain operating reserves

SRAD is helping preserve operating margins when generation resources are constrained. More frequent use makes reliable delivery increasingly valuable.

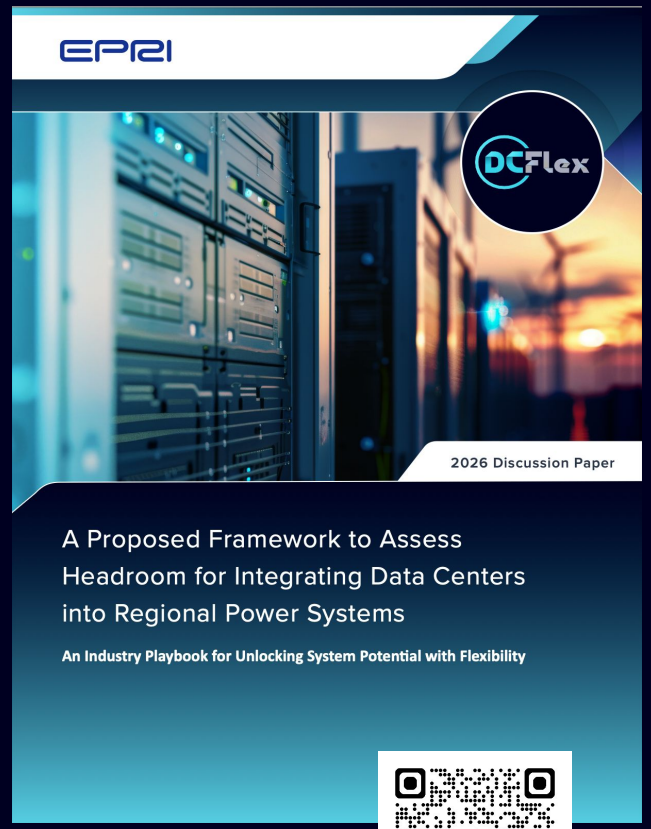


6th October: low renewable generation coincided with high thermal-generation unavailability, leaving insufficient upward reserve

Data source: https://srad.energy/

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How do we integrate Flex MOSAIC™ into the planning and operation?



www.headroom.epri.com

HEADROOM FRAMEWORK 101

A practical playbook to estimate system headroom

WHAT IT ASSESSES

More than peak-load capacity

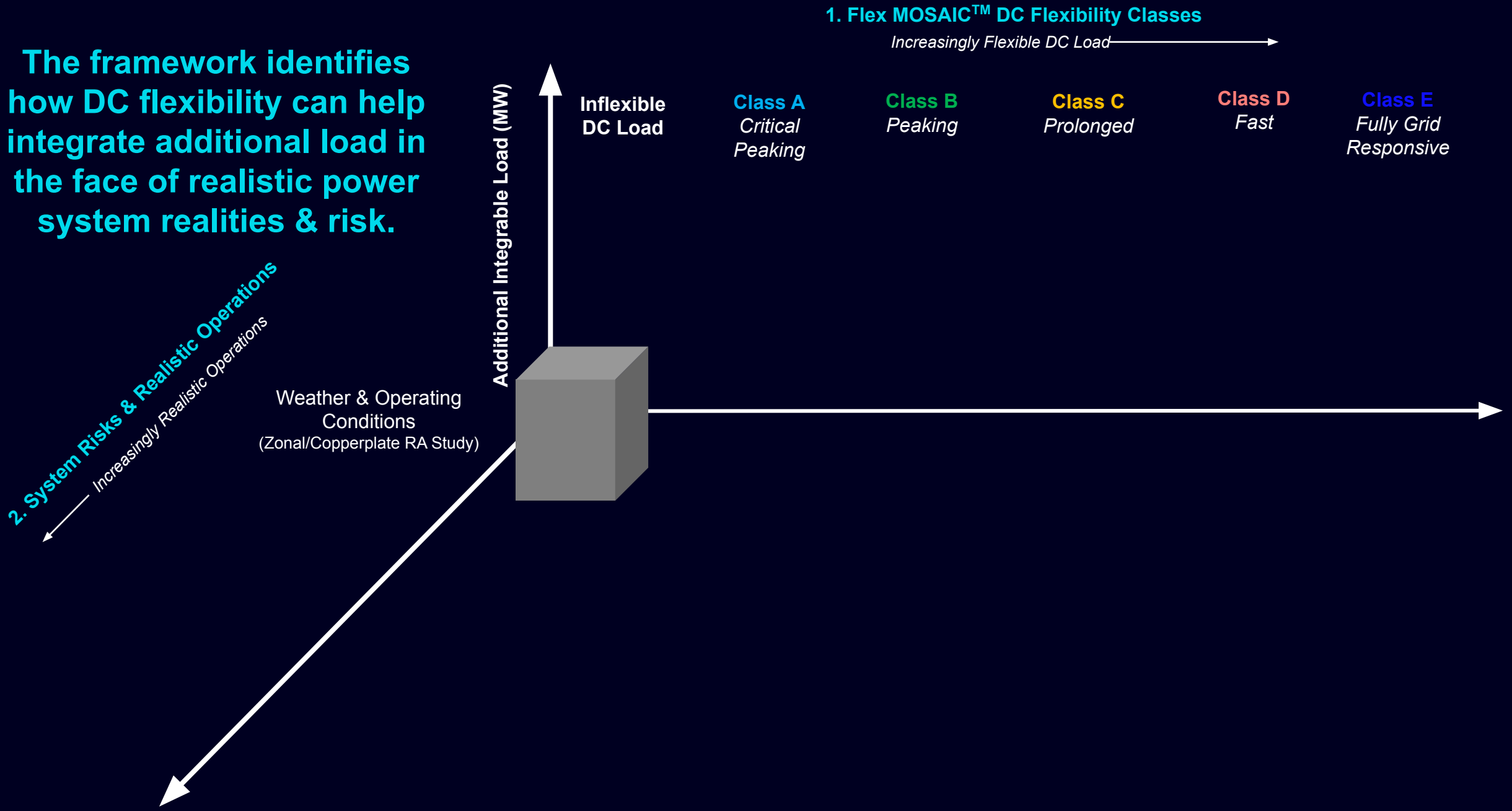
The framework assesses headroom along two key dimensions:

1. **Realistic power system characteristics** across relevant periods: system adequacy, generator constraints, transmission limits, fast-response operations, locational risk, and transmission reliability; and

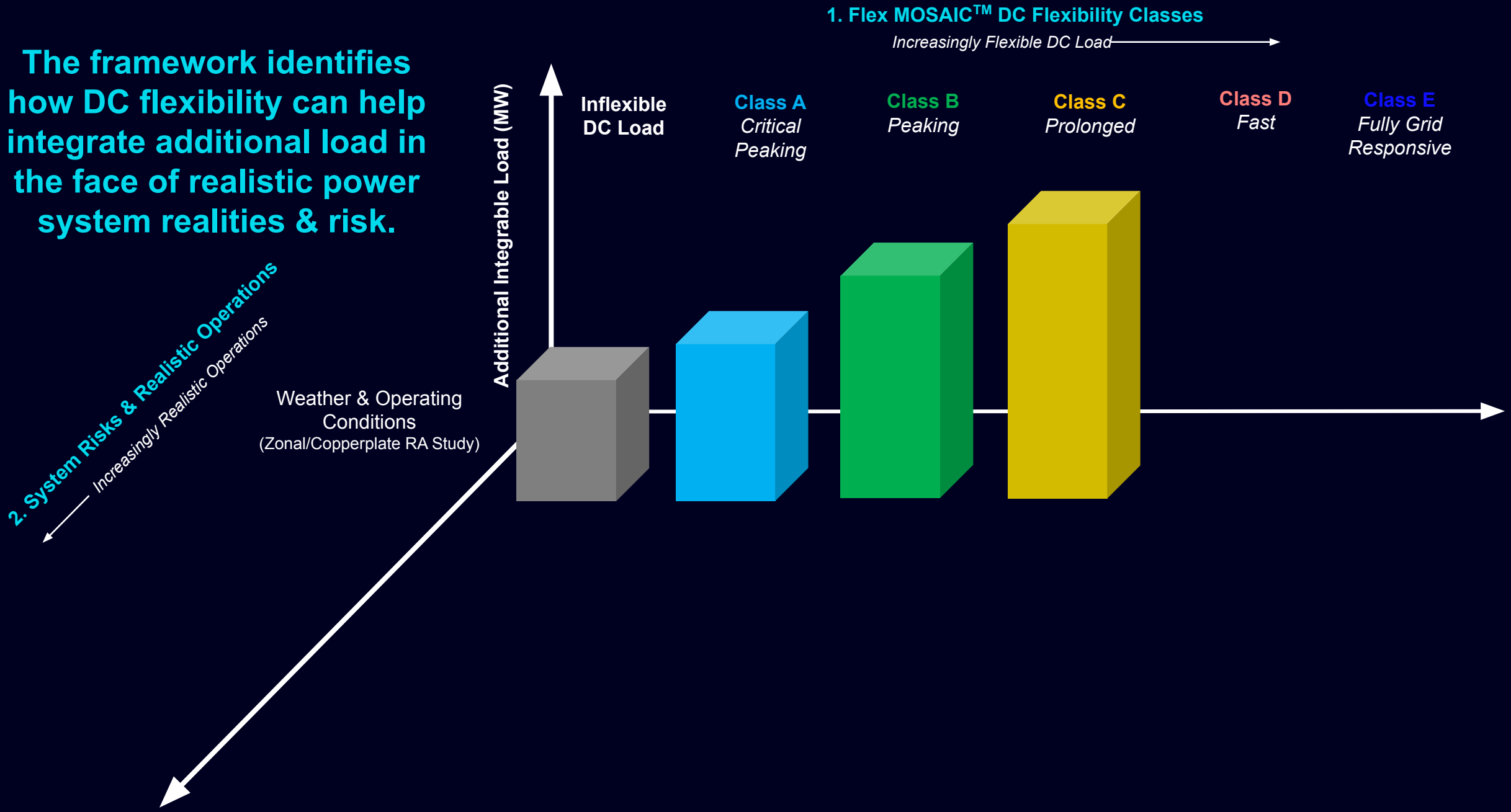
2. **Flexibility potential of the additional load**: the full range of Flex MOSAIC™ data center classes A-E, offering critical peaking to fully responsive grid support.

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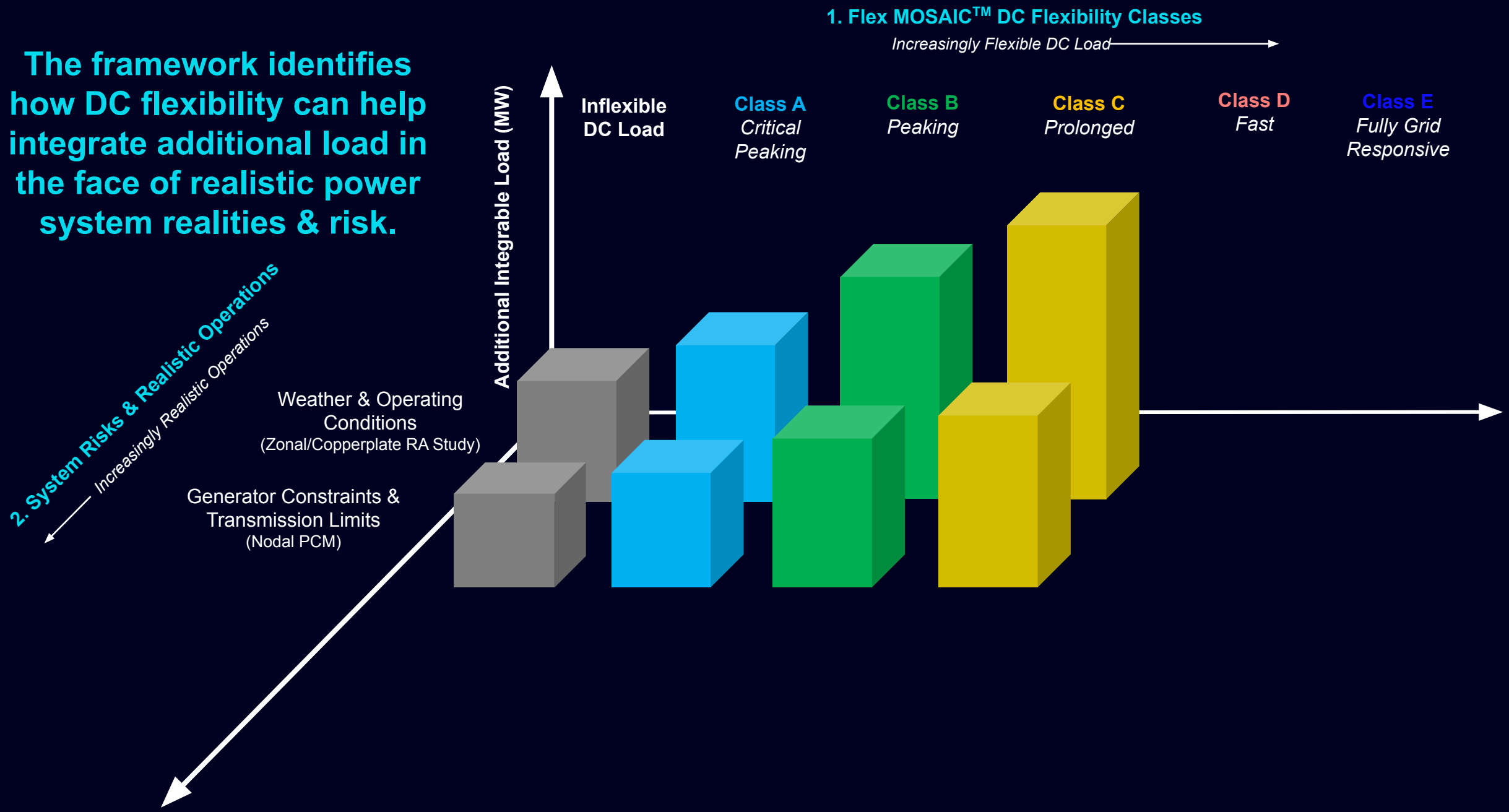
The framework identifies how DC flexibility can help integrate additional load in the face of realistic power system realities & risk.



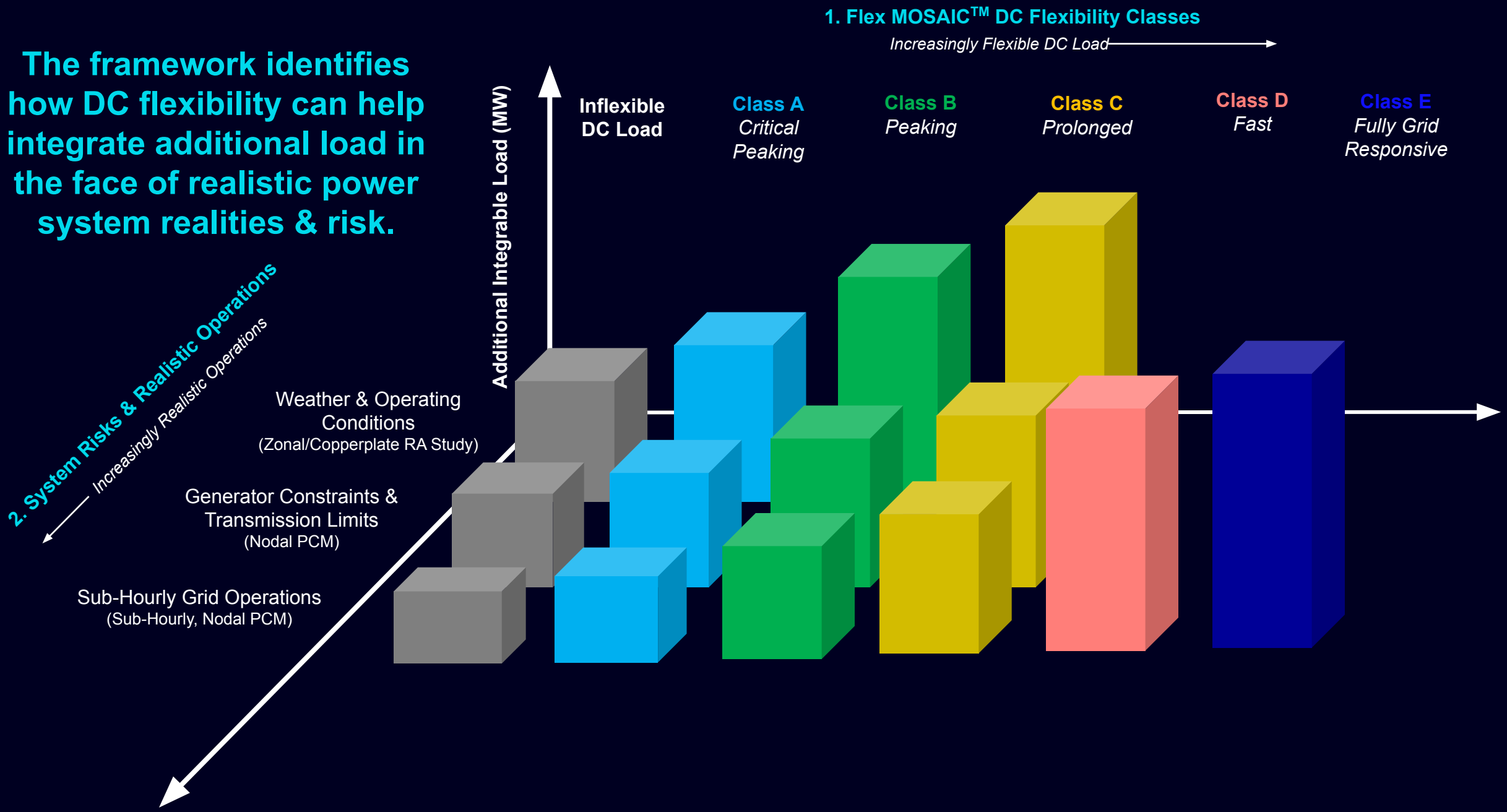
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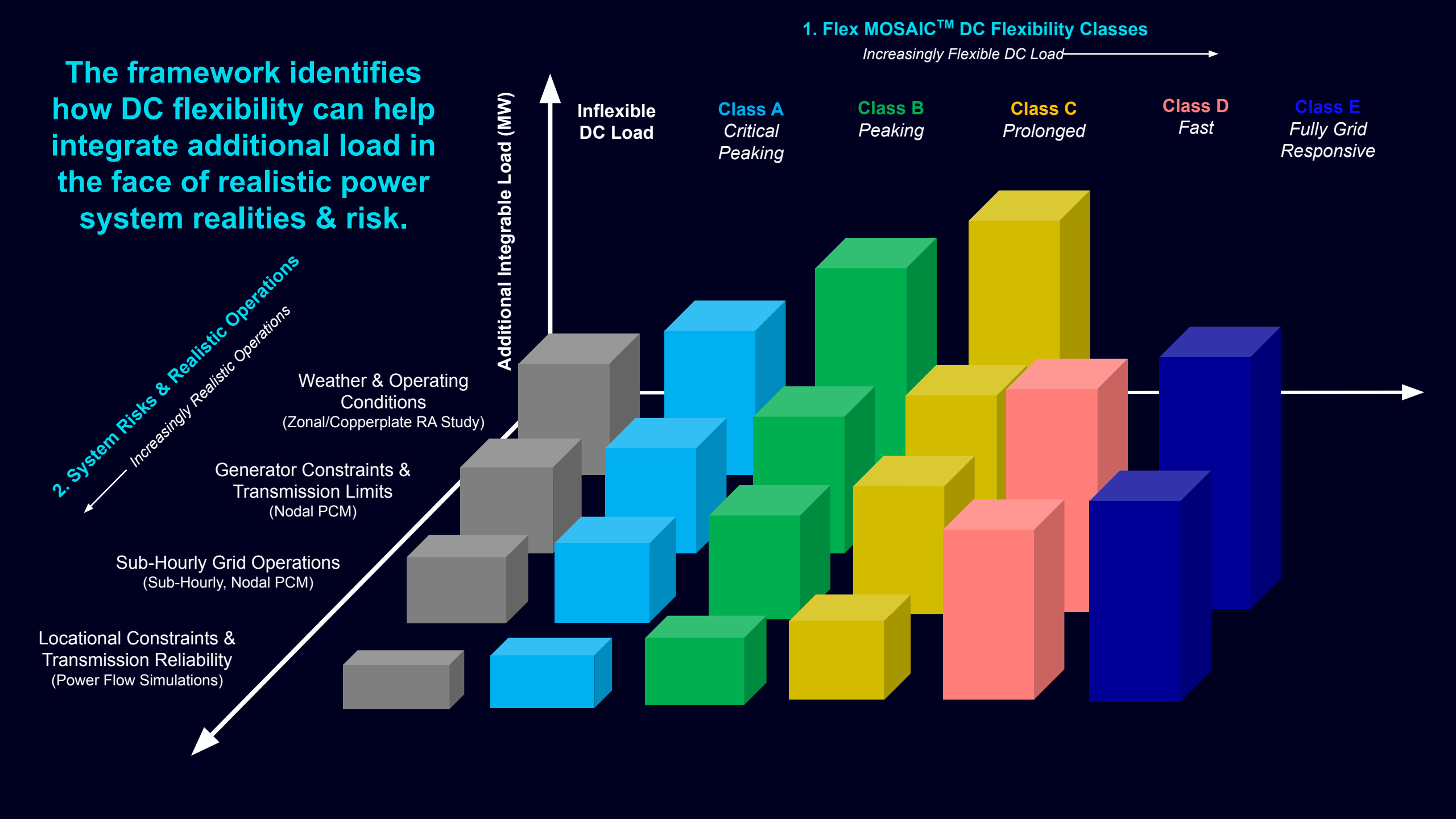


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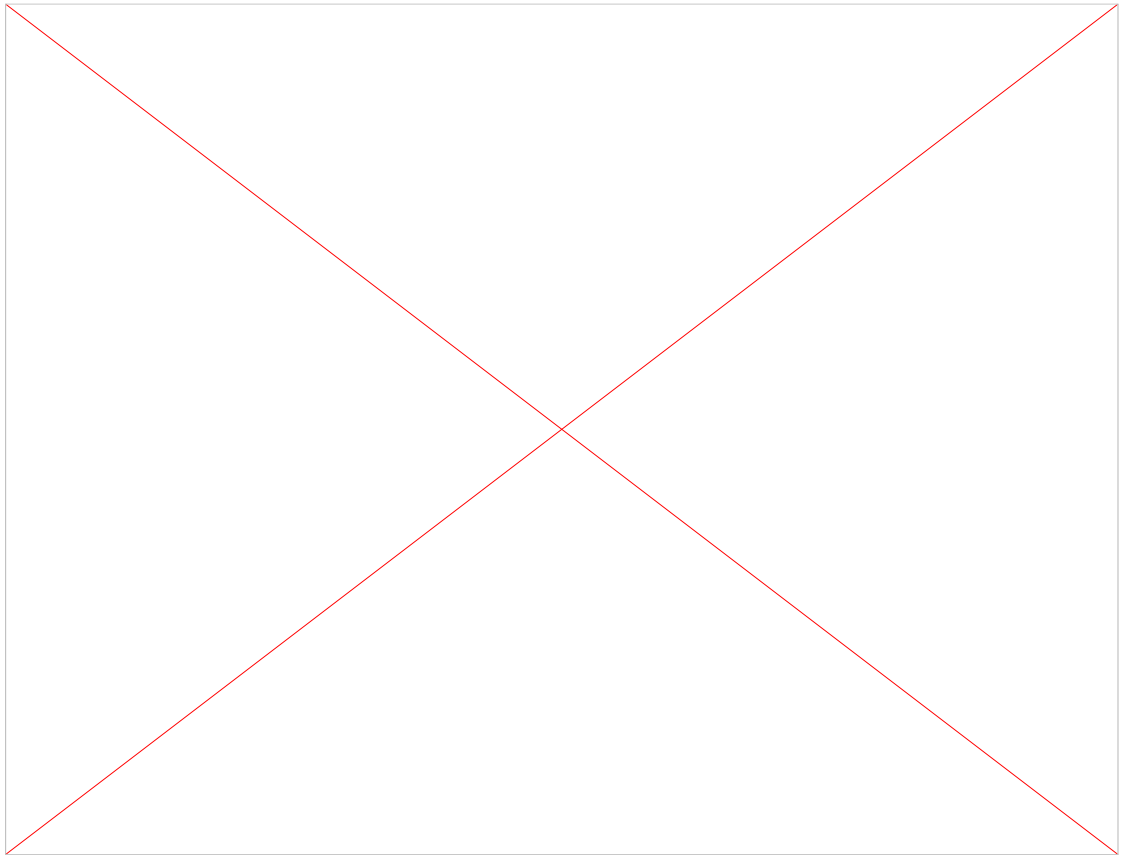


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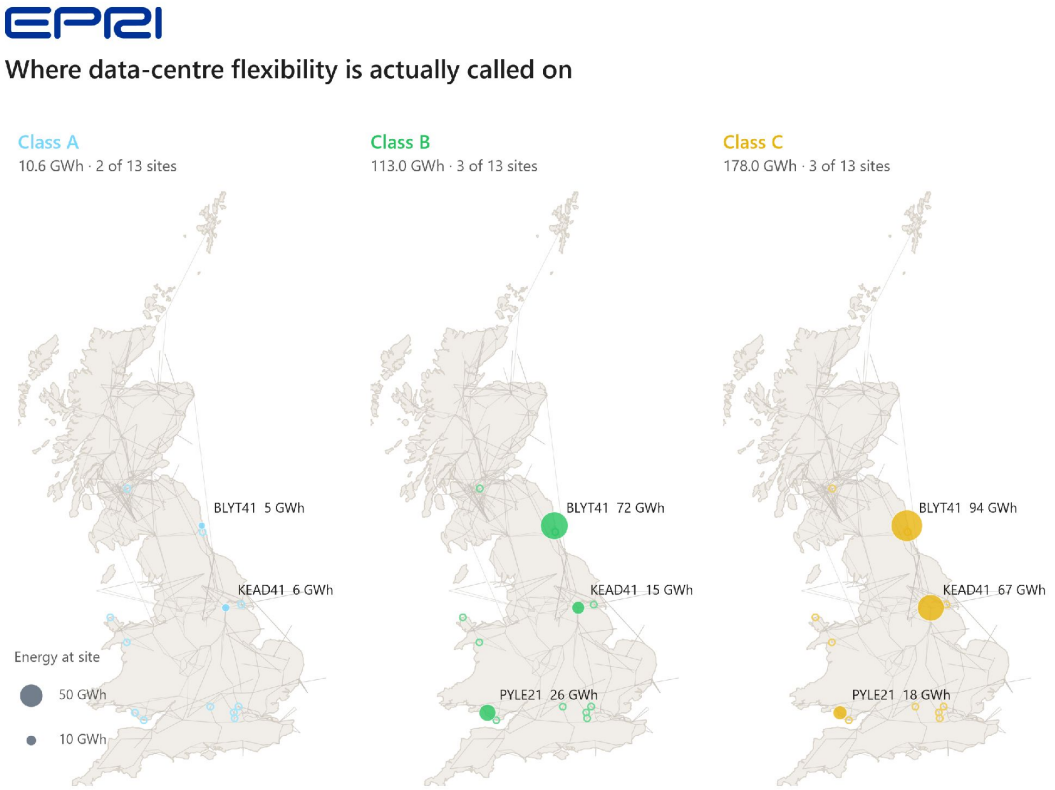



The framework identifies how DC flexibility can help integrate additional load in the face of realistic power system realities & risk.
1. Flex MOSAIC™ DC Flexibility Classes
Increasingly Flexible DC Load
Additional Integrable Load (MW)
Inflexible DC Load
Class A
Critical Peaking
Class B
Peaking
Class C
Prolonged
Class D
Fast
Class E
Fully Grid Responsive
2. System Risks & Realistic Operations
Increasingly Realistic Operations
Weather & Operating Conditions
(Zonal/Copperplate RA Study)
Generator Constraints & Transmission Limits
(Nodal PCM)
Sub-Hourly Grid Operations
(Sub-Hourly, Nodal PCM)
Locational Constraints & Transmission Reliability
(Power Flow Simulations)

Enabling new DC demand connection in GB



Source: https://flare.epri.com/



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What about Colombia?

Colombia has a DR foundation; a reliable response must be matched to each system's needs

COLOMBIAN EFFORT	FOUNDATION ALREADY AVAILABLE	REMAINING GAP TO ADDRESS
DDV [1] and critical-condition RD [2]	Firm-energy backing and scarcity response	Comparable MW, duration, availability and repeatability
Permanent wholesale RD [3]	Hourly offers, aggregation and day-ahead activation	Additional pathways for short-notice operational response
Temporary emergency RD [4]	Reductions during drought and fuel-supply stress	Sustained delivery beyond individual daily commitments
DER network-service policy [5]	A policy route toward local services and network alternatives	Procure specific services and verify electrical effectiveness

Emergency schemes are temporary applications. Network services remain a policy pathway.

Define where, when and for how long loads can respond, and how reliably they can deliver

[1] CREG 101 019/2022 [2] CREG 011/2015, as amended [3] CREG 101 111/2026
[4] CREG 101 043/2024, 101 054/2024, 101 084/2025, 101 115/2026 [5] MME 40283/2022, Arts. 11–12 and 14–15

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Use Flex MOSAIC™ to turn Colombia's flexibility potential into services that planners and operators can rely on

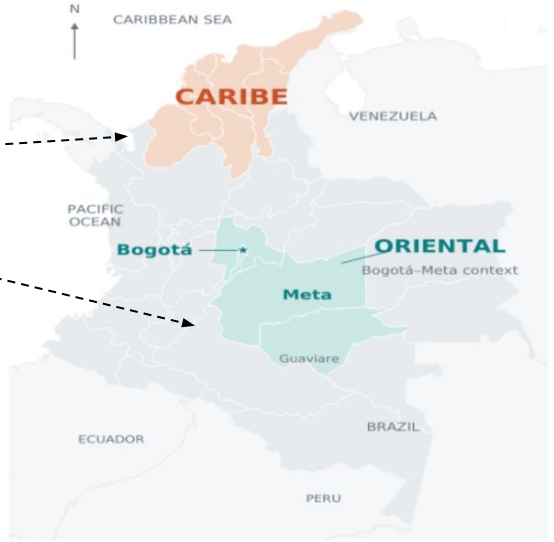
POTENTIAL ALIGNMENT	COLOMBIAN STARTING POINT	REMAINING GAP TO ADDRESS
A Critical peaking	Critical RD [2] and selected DDV [1]	Duration, availability and repeatability
B Peaking	Wholesale RD [3] participants	Short-notice operational response
C Prolonged	Selected DDV [1] and emergency loads [4]	Sustained response, energy and recovery limits
D Fast	A future operational-service pathway	Short-notice control and verified response

[1] CREG 101 019/2022 [2] CREG 011/2015 [3] CREG 101 111/2026 [4] Temporary RD: CREG 101 043/2024 and later schemes
[5] MME 40283/2022 [6] EPRI Flex MOSAIC. Tentative alignment. Local benefits require verification. Full references in notes.

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Use Flex MOSAIC™ to turn Colombia's flexibility potential into services that planners and operators can rely on

POTENTIAL ALIGNMENT	COLOMBIAN STARTING POINT
A Critical peaking	Critical RD [2] and selected DDV [1]
B Peaking	Wholesale RD [3] participants
C Prolonged	Selected DDV [1] and emergency loads [4]
D Fast	A future operational-service pathway



DRY PERIODS · ENERGY AVAILABILITY

The opportunity is to use a common language to define the response, verify its value, and make flexibility something Colombia can confidently call on

[1] CREG 101 019/2022 [2] CREG 011/2015 [3] CREG 101 111/2026 [4] Temporary RD: CREG 101 043/2024 and later schemes
[5] MME 40283/2022 [6] EPRI Flex MOSAIC. Tentative alignment. Local benefits require verification. Full references in notes.

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