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Envisioning a National Grid Flexibility Programme for India

March 2026

Rocky Mountain Institute (RMI) is an independent, nonpartisan nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to secure a prosperous, resilient, clean energy future for all. In collaboration with businesses, policymakers, funders, communities, and other partners, RMI drives investment to scale clean energy solutions, reduce energy waste, and boost access to affordable clean energy in ways that enhance security, strengthen the economy, and improve people's livelihoods. RMI is active in over 50 countries.

All India Discoms Association (AIDA) is a not for profit collaboration platform representing a wide spectrum of electricity distribution entities of India. Our members are state government owned Distribution Companies, private sector Discoms, Electricity Departments of Union Territories and Franchisees.

AIDA serves as the unified voice of all electricity distribution entities in the country serving 345 million electricity consumers. Our core objectives include fostering collaboration among members, advocating for progressive policy and regulatory reforms, and driving holistic development across the power distribution sector.

Foundation for Interoperability in Digital Economy (FIDE) is a not-for-profit organisation that fosters innovation and co-creation among ecosystem participants by building interoperable open protocol specifications as a public good. It is the genesis author of the Beckn Protocol specification, which is open-source and underpins open, decentralised commerce networks like the Open Network for Digital Commerce (ONDC). FIDE's latest venture, the Unified Energy Interface (UEI), is also built upon the Beckn Protocol and supports digital transactions of energy services, such as peer-to-peer energy trading, demand flexibility, and EV charging.

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Table of Contents

List of Abbreviations

AC	Air conditioning
ACDR	Automated demand response
AEEE	Alliance for an Energy Efficient Economy
AIDA	All India Discoms Associations
AMI	Advanced metering infrastructure
API	Application programming interface
BDR	Behavioural demand response
BEE	Bureau of Energy Efficiency
BESS	Battery energy storage system
CBA	Cost-benefit analysis
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
C&I	Commercial and Industrial
CSO	Civil society organisation
DEG	Digital Energy Grid
DER	Distributed energy resources
DERMS	Distributed energy resource management system
DF	Demand flexibility
DFPO	Demand flexibility portfolio obligations
DFS	Demand flexibility service
DISCOM	Distribution company
DR	Demand response
EM&V	Evaluation, measurement, and verification
ERCOT	Electricity Reliability Council of Texas
EV	Electric vehicle
FERC	Federal Electricity Regulatory Commission
FIDE	Foundation for Interoperability in Digital Economy
FSP	Flexibility service provider
GW	Gigawatt
IES	India Energy Stack
ISO-NE	Independent System Operator - New England
IT	Information Technology
kW	Kilowatt

kWh	Kilowatt-hour
M&V	Measurement and verification
MCE	Marin Clean Energy
MW	Megawatt
NESO	National Energy System Operator
NGFP	National Grid Flexibility Programme
OEM	Original equipment manufacturer
PPAC	Power purchase adjustment cost
SERC	State electricity regulatory commission
SO	System Operator
SOP	Standard operating procedure
TOU	Time of use
TRC	Total resource cost
UEI	Unified Energy Interface
VPP	Virtual power plant
VRE	Variable renewable energy

Foreword

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AIDA has a strong collaboration with RMI. I am delighted that RMI is publishing this white paper, 'Envisioning a National Grid Flexibility Programme for India.' This paper signals a defining moment as we transition from traditional power distribution to managing a complex, bidirectional, and decentralised grid.

The challenges facing DISCOMs today are multi-faceted—from record-breaking peak demand to volatile short-term power procurement costs, while navigating operational complexities arising from variable renewable energy (VRE). Grid flexibility emerges as a powerful tool for maintaining grid stability, reducing peak demand, and mitigating financial stress.

The National Grid Flexibility Programme (NGFP) presented in this paper offers a transformative vision for implementing demand flexibility efficiently, cost effectively, and at scale across a wide spectrum of DISCOMs. It proposes the development of an open, interoperable distributed energy marketplace where flexibility providers, such as aggregators of EV charging stations, and flexibility buyers, such as DISCOMs, can transact seamlessly. The envisioned marketplace will be backed by an open-source digital public infrastructure (DPI) to support reliable, transparent, and verifiable delivery and settlement of demand flexibility services.

This white paper identifies the regulatory, technical, and commercial enablers required to make this vision a reality. The collaborative approach presented in the paper resonates well with AIDA's values and I firmly believe the NGFP can evolve into a cornerstone of India's distributed energy transformation. We, at AIDA, remain committed to working with all stakeholders to help realise the vision of the NGFP.

Alok Kumar

(Alok Kumar)
Director General
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Foreword

On behalf of RMI and FIDE, we are delighted to present this white paper, *Envisioning a National Grid Flexibility Programme for India*, which presents the vision and ambition of a transformative approach to implementing demand flexibility in India. With demand for electricity skyrocketing, this white paper comes at a pivotal time as grid operators seek innovative solutions to integrate renewable energy and maintain grid reliability.

India's electricity grid faces critical challenges. During the past summer, a record-breaking heatwave led to grid outages and surging power procurement costs. At the same time, the country's commitment to installing 500 GW of clean resources by 2030, primarily renewable energy, is making supply more variable. To address these complexities, demand flexibility, which enables load shifting or shaving from load resources like EV chargers and ACs to help balance the grid, will play a critical role.

The white paper addresses the need for a new approach to unlocking the full potential of demand flexibility by introducing the concept of a National Grid Flexibility Programme (NGFP). The NGFP aims to create a digital network for energy that facilitates the discovery and transaction of flexibility services seamlessly and efficiently. By connecting buyers of flexible capacity, such as distribution companies and grid operators, with sellers, such as aggregators of distributed flexible resources, the NGFP aims to establish a robust network where flexible capacity can be transacted at scale.

Further, the white paper identifies critical challenges and enablers to implementing the vision of the NGFP. Incorporating insights and learnings from discussions, workshops, and a convening involving several stakeholders, the paper highlights recommendations and action items for key decision makers. It is our belief that this white paper will catalyse a collective commitment to embrace an innovative new solution for scaling demand flexibility, thereby helping India meet its rising demand for energy reliably and sustainably.

We extend our heartfelt appreciation to our colleagues at RMI and FIDE, and our partners, for their incredible efforts in preparing this white paper and fostering stakeholder alignment. Grid flexibility is the need of the hour, and we are optimistic that our concerted efforts will drive the development of the NGFP forward.

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Executive Summary

India's power sector faces mounting challenges due to rising electricity demand, increasing renewable energy integration, and the urgent need for decarbonisation. Traditional supply-side solutions alone are proving inadequate to meet these evolving demands. Demand flexibility (DF), which enables altering electricity consumption in response to grid conditions, offers a cost-effective and scalable approach to improving grid stability and reducing costs.

Even though demand response (DR) — a subset of DF that refers to specific, event-based peak shaving — has been piloted numerous times across India, widespread adoption of DF has been limited. Factors hindering its growth include the lack of regulatory and fiscal incentives, scalable deployment models, standardised operating, contracting, measurement and verification (M&V) protocols, and limited distribution company (DISCOM) capacity.

Addressing these complexities and helping scale DF more effectively requires making it more financially attractive to provide DF, developing sustainable deployment models, and establishing a network where DF providers and buyers can interact and transact transparently. Further, supporting aggregators that can bundle sizeable flexible demand capacity and coordinate the despatch of individual resources can help enhance the grid benefits and viability of DF. These challenges are already being solved by the development of digital marketplaces to enable large-scale DF programmes, as witnessed in Great Britain where the world's largest flexibility market is operating.

This paper presents a new initiative called the National Grid Flexibility Programme (NGFP), which aims to create digital infrastructure built upon an open network architecture to enable the discovery, ordering, fulfilment, and post-fulfilment of aggregator-based demand flexibility services. It aims to present an approach that supports open standards, interoperability across resource types, and transparent M&V and settlement. Its structure will utilise a multi-layered framework comprising a Technical Architecture Layer (foundational IT/communication for asset registration, data exchange, and transaction processing), a Virtual Network Layer (for hosting NGFP), and a Market Programme Layer (market mechanisms and participation frameworks for aggregators, prosumers, and DISCOMs).

The NGFP's primary objectives will be to:

Leverage an open network to establish digital infrastructure for DF buyers to discover and obtain flexible capacity by interacting seamlessly and transparently with DF providers.

Enhance replicability of DF across DISCOMs and geographies based on standardised communication and transaction protocols, measurement & verification (M&V) frameworks, network participant registries and contracting agreements, and data access and security guidelines.

Establish a general-purpose sandbox to provide a controlled environment for DF providers, buyers, and regulators to test and refine DF initiatives through actionable data.

By 2027, the NGFP seeks to identify and enrol 1 gigawatt (GW) of DF potential and operationalise an aggregator model where third-party service providers consolidate DF capacity for DF buyers. The long-term vision is to scale this initiative across the nation to 5 GW by 2030, which will require proactive support from central- and state-level policymakers, regulators, and DISCOMs. The critical pillars of support for scaling the NGFP include:

Establishing a robust regulatory framework that creates a conducive environment for DF programmes to integrate in day-to-day grid operations, establishes standard cost-benefit analysis (CBA) guidelines, and supports transparent price discovery of DF services for buyers. DF regulations notified by the Maharashtra Electricity Regulatory Commission can serve as a blueprint (see **Exhibit 3**).

Testing and implementing an open communication standard to enable interoperability across DF use cases, providers, and geographies.

Developing credible national protocols for M&V of DF services and data sharing and privacy.

Building stakeholder capacity and expertise via technical workshops for prospective buyers, policy roundtables with regulators, and consumer outreach programmes to build awareness among all stakeholders about the value proposition and financial incentives of participating in DF programmes.

Building stakeholder trust in the NGFP by establishing robust mechanisms for oversight, governance, and routes for recourse for market players. Implementing a proof-of-concept DF project through regulatory sandboxing can also help build trust in the NGFP's DF solutions.

The NGFP is designed to work in concert with India's broader digitalisation efforts in the energy sector. The India Energy Stack (IES), a Ministry of Power initiative, aims to build digital public infrastructure for the power sector. Sharing the core foundations of the IES, including transparent discovery, open standards, and interoperability, the NGFP represents a domain-specific application of these principles for aggregator-based DF. As the IES landscape matures, the NGFP is well-positioned to demonstrate DF as a critical use case for unlocking a digital energy future. The success of the NGFP will benefit DISCOMs and consumers, enhance grid resilience, help India achieve its ambitious clean energy goals, and set a precedent for integrating DF into modern power systems globally.

Introduction and Purpose of Paper

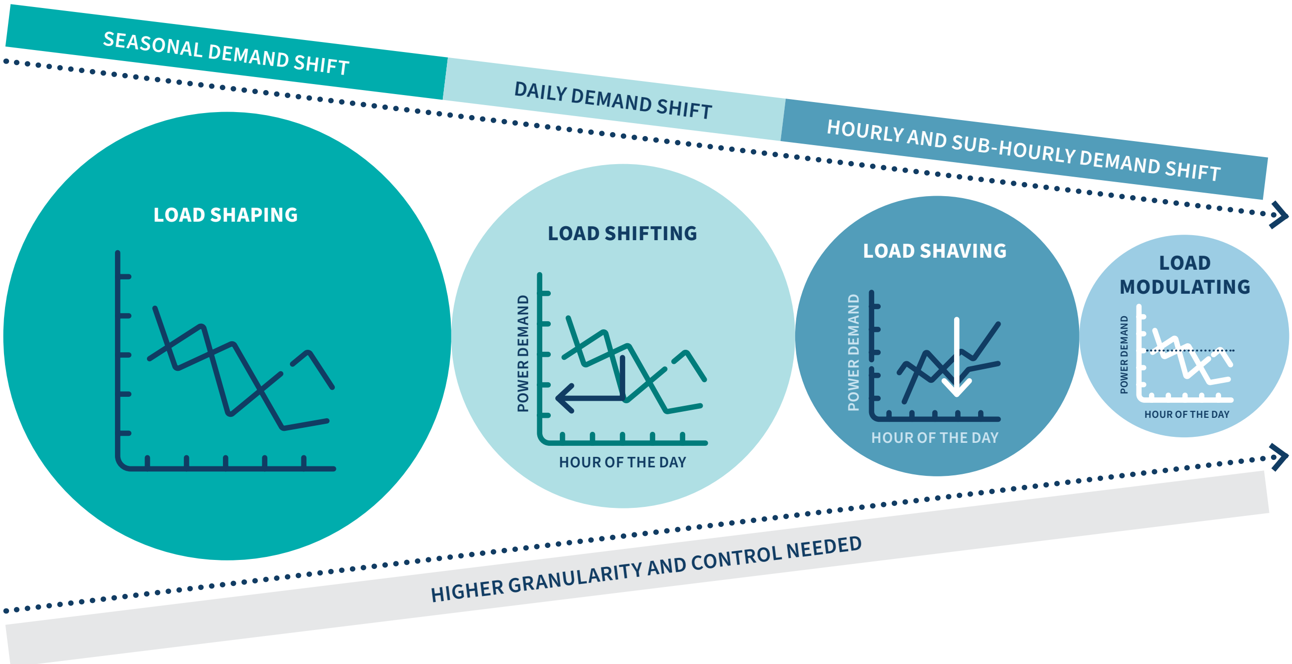
The summer of 2024 brought unprecedented challenges to grid operators across India as they grappled with meeting soaring peak demands driven by extreme heat waves. The northern region of India experienced a new high of 90 gigawatt (GW) peak demand on June 17, 2024, pushing past the previous year's peak demand of 80 GW.[1] This surge in demand led to widespread power outages and strain on the system, with several states resorting to load shedding to maintain grid stability. The effects of these extreme events were not limited to system-level challenges. At the distribution level, transformer failures spiked due to prolonged heavy loading and high temperatures.

As India faces a future of rising electricity demand and increasingly frequent extreme weather events, it is becoming both economically and environmentally unsustainable to meet peak demand through traditional supply-side solutions. The growing integration of variable renewable energy (VRE) sources, while essential for India's decarbonisation goals, adds another layer of complexity to grid management.

In this context, demand flexibility (DF), which refers to the ability to alter electricity consumption in time, location, or magnitude in response to grid signals, emerges as a powerful tool to address these challenges. This capability can take various forms, including load shaping, load shifting, load shaving, and load modulation (or "shimmy"), each serving different grid needs (see **Exhibit 1**).[i]

i. Load modulation (or "shimmy") refers to miniscule adjustments to load for short durations (sub-seconds to seconds) in response to signals from the grid operator to help regulate system frequency.

Exhibit 1 Overview of demand shifting enabled by grid flexibility measures



RMI Graphic. Source: RMI Analysis

Global studies have demonstrated the significant potential and cost-effectiveness of DF. For instance, a study by the American Council for an Energy-Efficient Economy (ACEEE) found that demand response (DR) programmes can reduce utilities' peak demand by an average of 10%, complementing savings from energy-efficiency programmes.[ii, 2]

Although DF is not a new concept, its adoption at scale has been limited in India. Successful examples, such as agricultural pumping load shifting to solar hours in Karnataka, demonstrated the potential, but they are isolated cases.[3] Widespread adoption has been hindered by the lack of regulatory and fiscal incentives, scalable deployment models, standardised operating and M&V protocols, and limited DISCOM capacity. These deficiencies have also eroded confidence in the reliability and value of DF resources.

ii. DR is a subset of DF and focusses solely on modulating or shifting load in response to grid conditions. DF can also include generation (or consumption) from behind-the-meter battery storage systems.

This paper proposes a NGFP to address these challenges and unlock the full potential of DF. The NGFP will serve as a digital layer, where DF providers and buyers, such as DISCOMs, can interact and transact. To facilitate transparent discovery and transactions, the NGFP will establish interoperability standards, standardised operating procedures, and clear M&V protocols. By creating a robust network for transacting DF services, it will aim to catalyse the aggregator model that has been fundamental to scaling DF effectively in global markets.

Aggregators play a crucial role by combining distributed energy resources (DER) and DF devices to enable fragmented and small-scale resources to participate in electricity markets and provide grid services.[4] The NGFP will provide a pathway for seamless interaction between aggregators and DISCOMs.

Realising this vision requires concerted action from all stakeholders in India's energy ecosystem. This paper incorporates insights from major stakeholders in the DF ecosystem in India and aims to catalyse action by identifying challenges and enablers for implementing the NGFP. The paper also identifies recommendations for key decision makers to drive adoption of the NGFP.

India's experience with DF

The DF landscape in India has been marked by fragmented demonstration pilots and limited enthusiasm from stakeholders. So far, the only effective demand-side programme has been irrigation water pumping load shifting in states like Karnataka, Maharashtra, and Gujarat. Collectively, the programme shifted over 6 GW of pumping load to daytime solar generation hours in 2020.[5] For example, Karnataka, which traditionally peaked in the evening, has experienced its peak load during daytime solar hours as a result of agricultural load shifting since 2020 (see **Box 1**).

Apart from the agricultural programme, several DISCOMs have explored diverse DF strategies as pilot or regulator-approved small-scale projects. While these have demonstrated the value proposition of DF, none has involved aggregators or achieved any appreciable scale. A summary of some of these programmes, which explored automated demand response (ADR) and behavioural demand response (BDR), is provided further below.

Regulator-approved commercial and industrial DF in Mumbai

Tata Power Mumbai conducted a small-scale, regulator-approved project that targeted commercial and industrial (C&I) customers, including the Chhatrapati Shivaji Airport, private commercial offices, IT parks, and the local municipality (sewage works) in Mumbai in 2012. Tata

Power Mumbai called 21 DR events of two hours each, which resulted in 15 MW of cumulative load reduction. The airport raised its air-conditioning (AC) temperature, commercial spaces shut off chillers after engaging in precooling, IT parks switched to back-up diesel generation, and the municipality conducted staggered sewage pumping. This project was an example of manual DR, but no incentives were offered to participants.[6]

ADR pilot in Delhi

BSES Rajdhani conducted an ADR pilot project in Delhi in the summer of 2021 with 22 residential and C&I customers. The project was implemented in two phases for residential customers, initially targeting automated AC-based DR through smart plugs and infrared (IR) blasters and then automated shfiting of water heating loads (geysers) to early morning hours using smart plugs. C&I customers only participated in peak shaving events. The project also developed a web-based platform and a mobile application for customer onboarding and engagement. The programme achieved a maximum peak load reduction of 1 megawatt (MW) and, like the Tata Power Mumbai pilot, offered no financial incentives to participating customers.[7]

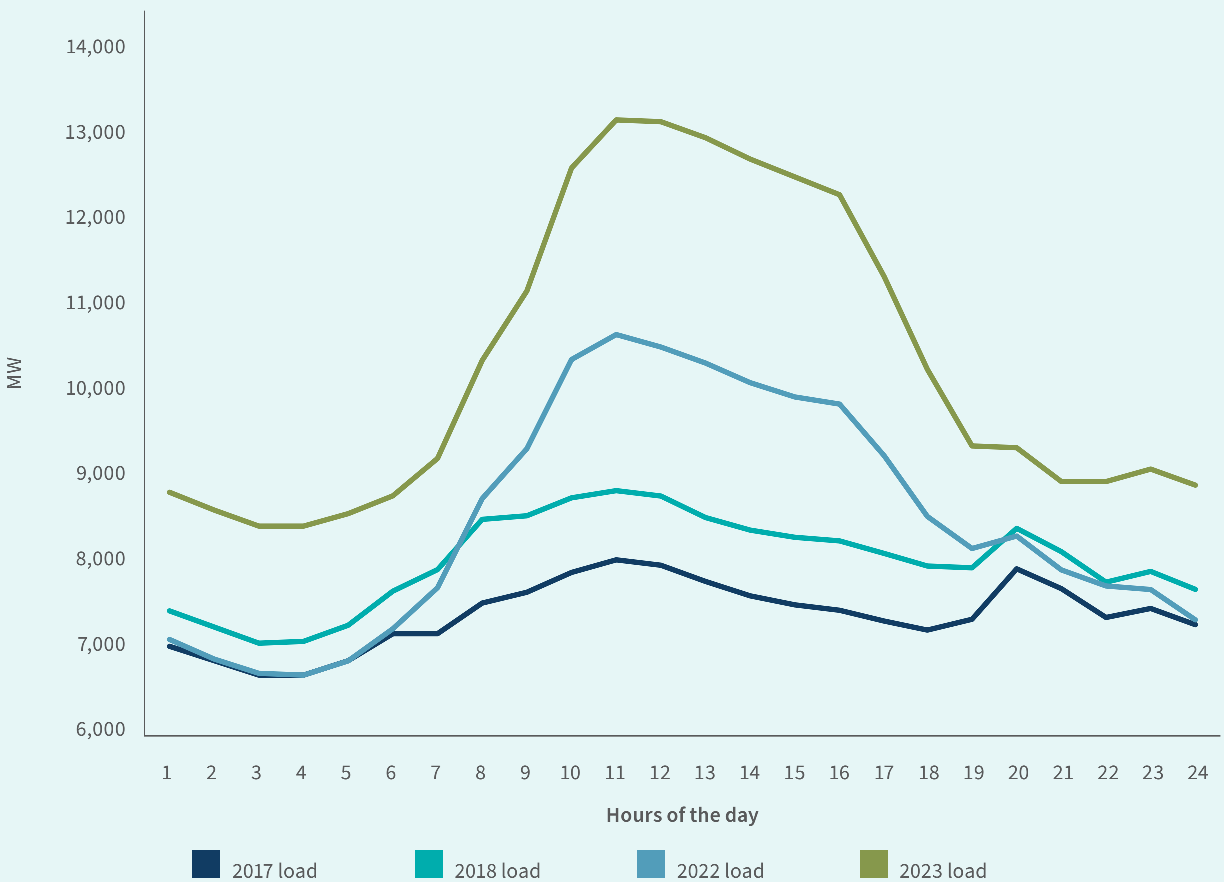
BDR pilot in Delhi

Tata Power-DDL initiated a BDR pilot in Delhi in 2022 with 2,000 customers and eventually scaled the programme up to 1,01,000 residential and C&I customers in 2024. The programme employs mobile application notifications, SMS, WhatsApp, and one-to-one calling to inform participants of upcoming peak shaving events. Participants then engage in voluntary load reduction during the event window. In FY2024, the programme achieved an average participation rate of 27% and average load shed of 35 MW (1.5% of Tata Power-DDL's peak load) across 16 events. While the programme provides no financial incentives or rebates, participants are rewarded via gift vouchers and lucky draws.[8]

Box 1 Agricultural demand flexibility: an Indian success story

India has achieved commendable success in shifting nighttime agricultural load to solar hours to improve grid reliability. Traditionally, power for irrigation pumping is provided at nighttime to keep a stable base load for coal generation. However, through a combination of financial incentives, tariff structures, surplus energy buyback programmes, and solar subsidies, farmers are increasingly incentivised to shift water pumping to solar hours. For example, the Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan scheme provides up to a 90% subsidy for solar irrigation pumps and offers ₹1.50–₹3.50/kilowatt-hour (kWh) buyback for excess solar energy. Similarly, in Gujarat, the Suryashakti Kisan Yojana scheme subsidises the installation of solar panels on farmland and guarantees ₹7/kWh buyback for excess solar energy for the first seven years and ₹3.50/kWh thereafter for 18 years. Other measures include restriction of free electricity for irrigation to daytime hours through time of use (TOU) tariffs and feeder segregation to supply power for irrigation only during daytime hours through dedicated agricultural feeders.

Exhibit 2 Impact of agricultural DF on Karnataka's hourly load curve



Source: NITI Aayog India Climate & Energy Dashboard, RMI Analysis

Limitations in India's DF efforts

India's successful agricultural DF programme and several global case studies offer insight into current challenges and possible ways for scaling up DF effectively in the country. For DF to truly scale in India, programmes have to be purpose-agnostic and move beyond siloed and non-interoperable solutions. While agricultural load shifting, like the 6 GW shifted for irrigation in states such as Karnataka, has been effective, it remains a singular, purpose-specific programme. This highlights the need for a comprehensive framework that integrates diverse energy needs, rather than isolated, non-transferable initiatives. Some of the key barriers to scaling DF, along with relevant lessons from fruitful case studies, are highlighted below.

Limited regulatory guidance

India's regulatory framework introduces multiple barriers to enabling DF programmes at scale. First, the tariff mechanism provides scant incentive to DISCOMs to invest in DF. A surcharge, called the Power Purchase Adjustment Cost (PPAC), enables DISCOMs to pass on unexpected increases in power procurement costs directly to consumers. Consequently, they prefer to recover fuel and transmission surcharges by billing customers rather than lowering costs through DF. For example, in July 2024, the four DISCOMs in Delhi experienced a significant increase in power procurement costs due to rising fuel prices. The Delhi Electricity Regulatory Commission approved PPAC of between 35.83% and 38.75% for the DISCOMs, resulting in consumer bills swelling by 6.15%–8.75%.[9]

Second, consumers have little interest in participating in DF programmes to lower energy bills as residential electricity rates in India are some of the lowest in the world. The absence of residential time-of-day tariffs further lowers the incentive for consumers, as potential bill savings would be minimal. On the other hand, DISCOMs hesitate enrolling C&I consumers (who are ideal for DF programmes due to their high electricity consumption and potential for savings) in DF programmes due to a potential reduction in the volume of C&I energy sales that could lead to revenue losses.

Finally, regulators lack the confidence to support DF as a reliable, cost-effective resource for power system planning due to the uncertainty associated with it. Consequently, regulatory approvals for DF have been cumbersome to acquire, and market players have focussed on capital expenditure (capex) investments on grid infrastructure to meet growing demand.

DF regulations, published in 2024 in Maharashtra and other states, offer a blueprint for proactive regulatory intervention to promote DF. The regulations propose DF portfolio obligations (DFPO) that mandate state DISCOMs to meet a certain percentage of peak load from DF and lay out clear guidelines on monetary incentives and penalties for DISCOMs, cost-effectiveness methodologies, and M&V of DF, as described in **Exhibit 3**.

Exhibit 3 Recent state of DF regulations in India

Attribute	Maharashtra	Assam	Andhra Pradesh
Resource classes/ end-uses	No restrictions on resource classes, e.g., smart EV charging, time-based irrigation pumping, etc.		
DF aggregator eligibility	Aggregators clearly defined and roles outlined.		"Energy services company" defined as provider of load management services
DF portfolio obligations (DFPO) or targets	DFPO prescribed as a percent of peak load, starting at 1.5% for FY 2025–26 and ramping up to 3.5% for FY 2029–30.	DF targets to be decided by Commission following load and DF assessment by DISCOMs.	
Discom cost recovery	DISCOMs allowed to recover net incremental costs of DF programs through annual revenue requirement (ARR) filings.		
Discom incentives/ penalties	₹0.2 crore/MW incentive for every MW in excess of DF target. ₹0.2 crore/MW penalty for every MW deficient of DF target.	Commission to decide incentives at a later stage.	
DF cost-effectiveness tests	Clear guidelines based on standard tests used globally (e.g., total resource cost [TRC])	DISCOMs to propose.	
Evaluation, measurement, and verification (EM&V)	DISCOMs to propose EM&V plan according to standard global practices, including an assessment of co-benefits (e.g., emissions savings, etc.) Independent third-party agencies to verify EM&V reports.	DISCOMs to propose EM&V plan but no requirement for assessment of co-benefits. Independent third-party agencies to verify EM&V reports.	
Data privacy guidelines	No mention of data security and privacy.	Strict guidelines prescribed.	Same as Maharashtra.
Customer awareness and incentives	DISCOM to propose capacity-building and awareness campaigns and financial and non-financial incentives such as time-of-use (TOU) tariffs, critical peak pricing, etc.		

RMI Graphic. Source: RMI Analysis

Globally, Great Britain is emerging as a leader in progressive regulations promoting DF. Ofgem, the energy regulator in Great Britain, has proposed establishing a single register in which flexibility service providers (FSPs), or aggregators, can access more markets and offer better rates for owners of flexible resources, such as electric vehicles (EVs) and home battery systems. The proposal is intended to streamline onboarding of aggregators and create a "one-stop sign-up point" for DF aggregators.[10] The proposal builds on other regulatory enablers, including performance-based regulation that links a utility's financial incentives to its performance outcomes, TOU (time of use) tariffs and Demand Flexibility Service (DFS), a national flexibility market (see **Box 2,** page 24).[11]

Lack of standardisation and robust M&V protocols

Part of the difficulty in scaling up proven DF programmes across geographies stems from a lack of standardisation and interoperability, which has resulted in a fragmented landscape. DF programmes trialled in India have targeted specific end uses and customer classes in discrete, isolated pilots. Communication protocols between DF devices and DISCOMs, M&V frameworks, metering requirements, and customer engagement strategies were developed as stand-alone solutions for each pilot, with minimal consideration for interoperability and scalability. Consequently, the current market structure lacks a common protocol across key areas such as appliances, communication, planning and SCADA systems, and M&V. Further, with advanced metering infrastructure (AMI) still in early stages of deployment across India and a lack of standardised M&V methodologies, it is a challenge for DISCOMs to fully incorporate DF as a resource in power scheduling and grid operations.

Thus, improving the interoperability of appliances across multiple resource types and original equipment manufacturers (OEMs) could allow DF services to expand the reach of DF programmes. Standardisation of communication protocols, contractual requirements, collection of electricity data, product certification, DF participant registry, data privacy and cybersecurity, and development of standard operating procedures (SOPs) will help make DF programmes more replicable and easier to scale.

In addition to the DFS in Great Britain (see **Box 2,** page 24), "ConnectedSolutions," a multidevice DF programme set up by National Grid in Massachusetts and New York in the United States, demonstrates the benefits of standardisation and interoperability in scaling DF.

The utility contracts with EnergyHub, a distributed energy resource management system (DERMS) vendor, to integrate all types of DF resources in a single platform by establishing communication through open protocols and proprietary application programming interfaces (APIs) and providing 15-minute performance telemetry.[iii] This standardisation helped the programme enrol 1 lakh participants in just four months with less than US$500,000 up-front incentive. The programme now provides up to 250 MW of peak shaving benefits to National Grid.[12]

Limited DISCOM capacity

Insights from an ADR pilot in Delhi reveal that DISCOMs do not perceive DF as a reliable means of meeting peak demand. Further, a lack of subject matter expertise results in a narrow assessment of the benefits of DF that omits savings from generation and transmission and distribution capital expenditures deferral. All these factors lead to an inadequate understanding of the net benefits and cost-effectiveness of DF, leaving DISCOMs wary of investing in DF-enabling technologies such as AMI, smart plugs, or ADR systems.[13]

Limitations in DISCOM capacity and inadequate regulatory incentives have prevented the development of sustainable models that appropriately benefit DISCOMs and compensate DF participants at the same time. Learnings from numerous DF pilots and programmes have suggested that financial incentives can significantly increase customer participation, leading to higher impact.[14] Higher impact, in turn, boosts the net benefits of DF. An RMI analysis of an illustrative power system in the Mountain West region of the United States found that net generation costs are 20% lower in a system that effectively deploys DF.[15]

Great Britain can again serve as a blueprint for utilities that drive DF through innovative business models. Octopus Energy, its largest domestic electricity retailer, has built a strong reputation for fostering customer empowerment by providing flexible smart tariffs that reward customers to shift or shed load based on grid conditions (see **Box 2,** page 24). The company reports that it paid £54 million to over 6 lakh consumers in 2023 to reduce load during times when renewable generation was low.[16]

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iii. DERMS, short for DER management system, is a software platform that monitors, controls, and optimises DERs to provide grid services such as energy, peak shaving, etc.

Ineffective customer engagement

Limited DISCOM capacity has led to poor customer engagement. DF programmes can scale only if they garner widespread customer participation. Interviews with participants of an ADR pilot in Delhi revealed that customers lack knowledge of DR and DF programmes, worry about data privacy, hesitate handing control of their appliances to DISCOMs, and are sceptical about tangible benefits. Customers also indicated the need for monetary remuneration to incentivise them to participate, as well as frequent feedback solicitation and local community involvement to build a sense of partnership with the DISCOM.[17] Surveys abroad have gleaned similar insights. An RMI report found that by offering attractive financial incentives, streamlining enrolment, and allowing customers to retain control of their devices, Arizona's Cool Rewards smart thermostat programme has been able to connect almost 1 lakh thermostats with the ability to shed over 160 MW of load.[18]

Insufficient demand aggregation

Demand aggregation groups and despatches individual flexible resources as a single entity and provides grid services akin to a conventional power plant. These aggregations, also known as virtual power plants (VPPs), are critical to implementing DF in India, as individual households do not noticeably affect grid operations.[iv] However, insufficient regulatory uptake of aggregators, lack of financial incentives, lack of standardisation, and poor visibility of DF assets prevent aggregator-based models from taking off.

As highlighted earlier, agricultural load shifting is the only DF programme that has achieved significant scale. Committed regulatory action, including TOU tariffs, attractive financial incentives for participating farmers, and dedicated agricultural feeders drove the programme's success. Similar interventions for other end uses can facilitate aggregations of more DF resources, while standardisation of the DF provider registry, M&V, and cost-effectiveness can help stimulate the market for aggregators in the country.

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iv. A VPP is a decentralised network of DERs that are aggregated and managed as a single unit to provide grid services. These can include DF resources such as smart AC, managed EV charging, smart water heaters, etc., rooftop solar, and home battery energy storage systems (BESS).

Box 2 Great Britain’s push to become a DF leader

Great Britain has set an ambitious target of achieving full grid decarbonisation by 2030, and its electricity system operator has advised that DF should play a key role in integrating clean energy. Its modelling suggests that DF capacity must reach approximately 20% of peak demand, or 10–12 GW, by 2030 if its grid is to decarbonise.

To spur DF growth, Great Britain’s National Energy System Operator (NESO) operates a DFS that enables customers with smart meters to participate in the electricity market by providing incentives to reduce or shift load. Launched as a contingency toolkit in winter 2022/23, the DFS is now a year-round flexibility market that lowers entry barriers for DER and DF aggregations to participate in the electricity markets. In the winter of 2022/23, 1.6 million participants collectively provided ~350 MW of flexibility and reduced load by 2.92 GWh. The service presents a model case study for supporting the aggregator model, introducing standardisation in grid codes, metering requirements, incentive structure, and M&V and enabling interoperability by publishing clear API documentation. The energy regulator, Ofgem, has also proposed a single register for the DFS to streamline and accelerate onboarding of DF aggregators.

Octopus Energy, Great Britain’s largest domestic electricity retailer and a registered aggregator on the DFS, illustrates how innovative utility business models can internalise DF in day-to-day grid operations. The company specialises in dynamic tariffs designed to promote DF and bill savings. Facilitated through its proprietary platform, Kraken, it enables real-time monitoring and management of energy consumption. For example, one of its tariffs provides half-hourly pricing that reflects wholesale energy costs, encouraging customers to shift load to off-peak hours. Another tariff, tailored for EV owners, offers reduced overnight rates to support economical EV charging. It also participates in the DFS through the Saving Sessions programme that aggregates household DF resources such as BESS, EVs, smart thermostats, and smart heat pumps. In November 2022, it provided 108 MW of peak shaving from 2,00,000 customers. Since 2017, the company has won several accolades for its customer engagement and now serves 7.3 million customers, providing GW-scale flexibility capacity.

Great Britain’s focus on establishing a national flexibility market that supports the aggregator model and advances standardisation, interoperability, and simplified registry has already borne fruit. Along with progressive utility models that promote DF, such as Octopus Energy’s smart tariffs, Great Britain contracted 4 GW of grid flexibility services in 2023, making it the biggest flexibility market in the world.

The Great Britain example highlights how a concerted, multifaceted approach can help catalyse the market for DF. With the need to integrate 500 GW of non-fossil fuel-based resources, primarily VRE, by 2030, it is imperative that India expand DF services in its daily grid operations. Lessons learned from Great Britain's experience can serve as a beacon for India to follow.

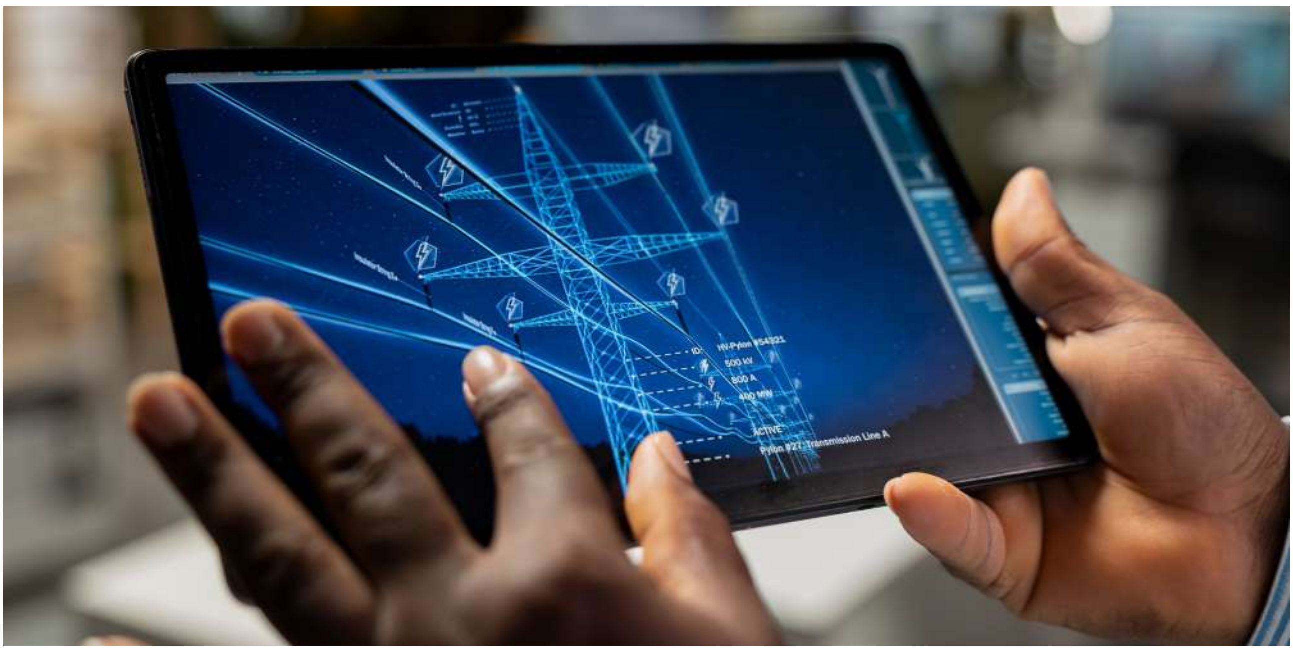
Limitations in market structure

India's ability to develop robust DF programmes is further hindered by fundamental market structure deterrents. The absence of a formal capacity market is a primary barrier, as it fails to provide long-term price signals that would incentivise investment in flexible demand. Second, the participation of DF or DF aggregations in ancillary services is in its nascency. Although CERC (Ancillary Services) Regulations, 2022, enable the participation of DF resources in ancillary services, there is a need for state regulators to adopt similar regulations to unlock DF participation in ancillary services markets. This structural void cripples any potential for sophisticated incentive design, leaving no clear business case for participation. Consequently, market participants, from aggregators to large consumers, are not compelled to invest in or offer DF services.

Since new participants are not onboarding, the entire ecosystem fails to achieve critical mass, creating an insurmountable issue of scalability. This lack of a supportive framework creates a debilitating cycle: without revenue streams, there are no service providers, and without a growing base of providers, the market cannot mature. This creates a vacuum where no entity is positioned to champion or develop DF programmes. The core issue is the absence of incentive loops that would naturally drive adoption and innovation. Ultimately, these structural deficiencies prevent India from establishing the necessary pathways for widespread DF adoption.

The NGFP: Pathway to DF Liftoff

The challenges that have hindered the growth of DF in India call for an innovative solution to implementing DF that transcends the traditional programmatic approach, advocating instead for a network-centric model. To effectively scale DF, an open network is required to form the basis for the NGFP. This network will provide the digital infrastructure to enable DF providers to aggregate diverse resources (e.g., DR, managed EV/e-bus charging, water pumping, battery storage) and buyers to discover and procure services from these aggregated resources on a unified network. This network can be built on Digital Energy Grid (DEG), which provides interoperability and composability as its core design principles.[v, 19] This will enable the energy ecosystem to move beyond piecemeal DF efforts, directly addressing the underlying lack of aggregation, standardisation, and interoperability. The following sections outline the purpose, scope, and primary enablers of the NGFP.



v. The Digital Energy Grid (DEG) aims to establish a foundational digital backbone for the energy ecosystem that digitises transactions, assets, and participants in an interoperable manner by introducing key principles such as universal identity, machine readability, and verifiability.

Purpose and scope of the NGFP

The NGFP's main goal is to support a resilient, cost-effective grid that can integrate high penetration of VRE by fostering innovation and investment in scalable DF technologies. By 2027, the NGFP aims to:

a. Discover 1 GW of DF potential across several lighthouse DISCOMs.

b. Operationalise the aggregator model, where third-party service providers bundle DF capacity and offer it to DISCOMs.

The NGFP would scale up to discover 5 GW of DF potential on the network by 2030, driving nationwide adoption. To achieve the above outcomes, the NGFP network will be positioned as an integrated digital layer that addresses the fragmented landscape of DF in India and solves for scalability. Its primary objectives will be to:

a. Leverage an open network to establish digital infrastructure for DF buyers to discover and procure flexible capacity by interacting seamlessly and transparently with DF providers.

b. Enhance replicability of DF across DISCOMs and geographies based on standardised communication and transaction protocols, M&V frameworks, DF provider registry and contracting agreements, and data access and security guidelines.

c. Establish a general-purpose sandbox to provide a controlled environment for DF providers, buyers, and regulators to test and refine DF initiatives through actionable data.

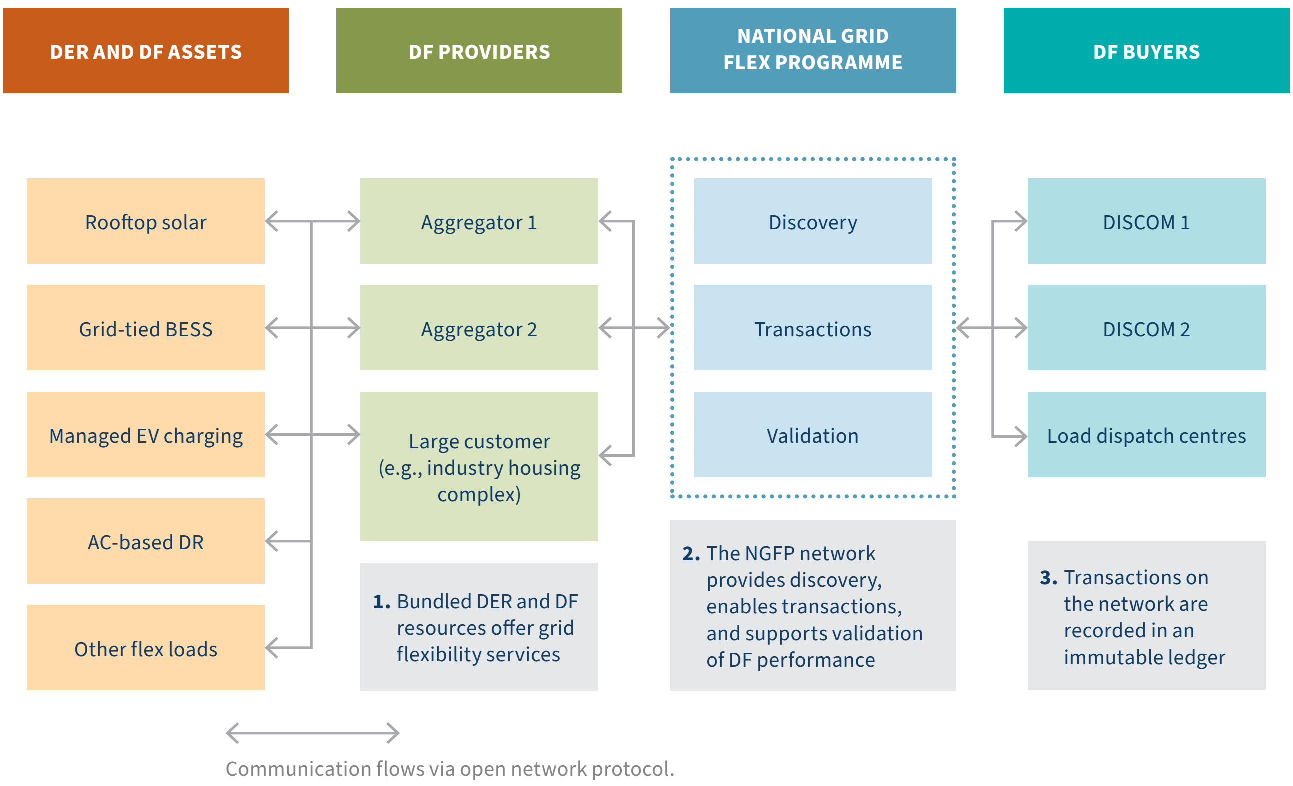
The open network underlying the NGFP will adopt a multi-layered approach to its development. This structure will consist of three main layers — a technical architecture layer, a virtual network layer, and a market programme layer. The technical architecture layer will provide the essential IT and communication protocols for asset registration, data exchange, and transaction processing. The virtual network layer will host the NGFP, enabling discovery, ordering, fulfilment, and post-fulfilment of DF services. Finally, the market programme layer will create market mechanisms and participation frameworks for market actors, including aggregators, prosumers, and DISCOMs.

Observability will be a key guiding principle for NGFP open network facilitators. Incorporating observability will ensure the NGFP network makes DF performance verifiable, failures diagnosable, and outcomes auditable.

Furthermore, as the demand for artificial intelligence (AI) in India's power sector increases, the NGFP architecture will incorporate vital AI applications (including but not limited to RE forecasting, demand forecasting, network overloading, digital twinning, etc.) that can be developed by market participants and scaled for DISCOMs and grid operators connected to the network.

The development and adoption of a standardised communication and transaction framework, such as OpenADR, IEC 61850, or Unified Energy Interface (UEI), will play an important role in the development of the NGFP. UEI, an open energy network to enable transactions between digital energy systems, presents a promising homegrown solution for interoperability. Built on the Beckn Protocol, which underpins other open networks, such as the Open Network for Digital Commerce, it creates a unified ecosystem where providers and consumers of energy-related services, such as DF and EV charging, can communicate and transact seamlessly.[20] **Exhibit 4** provides an overview of the NGFP, built on an open network architecture such as UEI.

Exhibit 4 NGFP operational flow



RMI Graphic. Source: RMI Analysis

Design principles of the NGFP

For a robust, adaptable, and scalable approach to advancing India's DF ecosystem, the following core design principles are crucial. These principles are specific to the unique needs of the energy sector's DF landscape, particularly when building on DEG:

Vendor-agnostic, specification-driven architecture

The architecture for DF solutions must be based on well-defined, comprehensive specifications that various vendors of smart appliances, metering devices, and software can adhere to. This prevents lock-in to proprietary systems and incompatible technologies, fostering a competitive market for DF services and devices. For instance, standardised communication protocols for smart thermostats or EV chargers would allow any device to seamlessly integrate with a central DF network, much like Unified Payments Interface-enabled diverse payment apps.

Technology-agnostic architecture

The DF network's architecture must not be tied to any specific technology. This ensures its long-term viability and adaptability, allowing for the easy integration of new and emerging DF resources — whether it's advanced battery storage systems, vehicle-to-grid, or future smart home devices — without requiring a complete system overhaul. This flexibility is key to harnessing India's diverse and evolving energy demand landscape.

Open data and observability

A robust DF network must emphasize open data principles and comprehensive observability. Making data on consumption, generation, grid conditions, and DF event performance accessible (while ensuring privacy) fosters transparency and continuous innovation. This allows third-party developers, researchers, and aggregators to build new applications, optimise DF strategies, and create rich insights, much like how Transport for London's open transit data spurred extensive app development, ultimately benefitting the entire transport system and its users.

Federated governance

The network's architecture should promote a federated governance model, recognising the autonomy of various geographical and institutional stakeholders, including DISCOMs, state regulators, and local communities. This allows each entity to manage and optimise local DF programmes according to specific regional needs and grid conditions, while still adhering to overarching national standards and protocols established by the NGFP. This decentralised approach ensures greater responsiveness and local relevance while maintaining overall system coherence.

Composability

This enables the DF system to be assembled from smaller, independent components. This allows for the easy creation of new DF services and optimisation strategies by combining existing data streams and resource types. For example, integrating data from smart meters, rooftop solar generation, EV charging patterns, and industrial load profiles can yield powerful applications for peak shaving, grid balancing, or renewable energy integration, unlocking true innovation and efficiency across the energy ecosystem.

By using these principles, the NGFP can be built fundamentally on DEG for inherent interoperability and composability and can transcend current siloed approaches and unlock India's vast DF potential.

Core capabilities of the NGFP

Discovery of flexible capacity

A hurdle to scaling DF in India has been a dearth of trust in the reliability and value of grid services provided by DF resources. With no effective means to identify and track DF resources on the network, DISCOMs are unable to ascertain the available DF potential. The NGFP will aim to enable the discovery of DF capacity on the distribution network, including visibility into location, operational status, and load shifting (or shaving) potential. These resources will be bundled by DF providers for DF buyers (e.g., DISCOMs and load despatch centres) to discover on the same network.

Further, it will incorporate universal registries that will be accessible to eligible DF providers to help them enrol and showcase their set of DF assets. The registries will establish universal onboarding procedures, including know-your-customer requirements, service and technical specifications, and data reporting standards. With new DF capacity discoverable, the NGFP will form a digital network for buyers to transact DF capacity.

Transactability

Using a common and unified protocol for transactions, the NGFP will establish an effective framework for buyers to procure and compensate DF services from providers. It will maintain a public, immutable ledger that records all DF transactions and aim to ensure quick, transparent, and just compensation for DF services.

Further, to increase its reach among DF buyers across the country, the NGFP will support multiple transaction models as long as they adhere to its national communication and transaction protocol. The most common models used internationally are an auction-based pay-as-bid model, a wholesale markets participation model, and a bilateral contract model. In the auction-based model, which was used in the now-discontinued Demand Response Auction Mechanism in California, providers submit offers of DF capacity through a transparent auction and are paid based on their bids. In the wholesale market participation model, used in deregulated energy and capacity markets such as in Great Britain, providers offer DF services directly in the electricity markets. Finally, in a bilateral contract model, providers and buyers contract with each other on a mutually determined compensation rate. In this regard, the NGFP will maintain a standard set of guidelines and templates of each supported transaction model. Examples of DF transaction models are provided in **Box 3**.[21]

Box 3 DF transaction models

Pay-as-bid model

In this model, DF providers submit bids indicating the price at which they are willing to shed load. If the bid is selected, the participant is paid the exact bid amount, subject to DF performance verification. This process ensures a competitive environment where multiple providers can vie to deliver the required flexibility services.

Piclo Flex, a flexibility marketplace-as-a-service platform, employs the pay-as-bid model via a competitive auction process to match DF bids from providers with the flexibility needs of utilities. The process encompasses several stages (more detail in the **Appendix A**):

1. Procurement of flexibility services
2. Qualification of FSP and flexible assets
3. Bidding
4. Post-bidding operations and despatch
5. Settlement

Piclo Flex operates in six global markets (Australia, the United Kingdom, the United States, Ireland, Italy, and Portugal) and has facilitated flexibility contracts totalling approximately US$75 million and more than 3 GW of capacity.

Wholesale market integration model

This model allows DF participants to offer grid services directly in the wholesale power markets alongside traditional generation resources. Participants may be paid for multiple grid services, including load reduction in the energy market, resource adequacy in the capacity market, and frequency regulation in the ancillary services market.

ISO New England (ISO-NE), the power system operator in the Northeastern United States, is pioneering wholesale markets' integration of DF resources. Following Federal Energy Regulatory Commission (FERC) Order 2222 that required grid operators to integrate aggregations of DERs in wholesale electricity markets, ISO-NE began revamping its enterprise systems and metering and telemetry requirements. It plans to incorporate DER and DF aggregations in the capacity market later in 2025 and have full participation in energy and ancillary services markets in November 2026.

Box 3 DF transaction models (continued)

Bilateral contract model

In this model, agreements specifying the terms, conditions, and compensation for load shedding or shifting are negotiated directly between the utility and DF providers. For example, the Base Interruptible Program in California uses this model to implement demand response among large C&I and agricultural loads (or their aggregations) with at least 100 kW of demand. Participants commit to a predetermined minimum load, called firm service level, which they must maintain during DR events. Using data from 15-minute or 30-minute smart meter telemetry, utilities compensate them based on the actual load shed measured in kW.

Standardisation and interoperability

One of the core value propositions of the NGFP for scaling DF in India is to implement standardisation and interoperability of DER and DF resources. Positioned as a unified digital infrastructure, the NGFP will bring standardisation in the following domains:

Communication protocol

Using a common and open network, the NGFP will implement a common communication protocol, ensuring interoperability and seamless integration of diverse DF resources. It will standardise communication across the following channels:

- **Provider-to-Network:** DF providers will compile data from their assets and transmit and receive data through the NGFP network, including operational status and availability, location, capacity, and DF event notifications.

- **Network-to-DISCOM:** The NGFP network will transmit and receive data to and from DISCOMs using a data language that is compatible with DISCOM IT systems.

Open-source APIs

An API is a set of rules and protocols that defines how requests for services or data are made between different systems and how those requests are processed. APIs allow developers to build on existing services without needing to fully understand their internal code. The NGFP will leverage an open API-driven architecture to allow interoperability and seamless integration between resource OEMs, DF providers, and DISCOM enterprise systems.

M&V

DF resources and aggregations must be able to deliver on their committed capacity, especially when grid operators face critical shortages of power supply and call on DF to balance the system. Thus, accurate measurement of performance is essential to build confidence among DISCOMs and regulators on the reliability of DF resources. To address this, the NGFP will establish a robust M&V framework that provides quick, consistent, and verifiable assessment of DF performance. This will involve adopting a standardised approach to meter data telemetry, uniform baselining methodology, and a clear performance tracking and verification process. One such open-source M&V methodology, OpenEEmeter, is described in **Box 4**.[22]

Grid services definition

The NGFP will codify grid standards as established by regulators, including, but not limited to, technical standards and operational requirements that all flexible resources or aggregations must meet to interact with the electricity grid. The NGFP may also provide a standard contract template between DF providers and buyers that includes a holistic set of grid codes, qualification requirements, performance guarantees, dispute resolution, and more.

Box 4 OpenEEmeter, an open-source M&V framework

OpenEEmeter is an open-source software framework designed to standardise and automate the M&V of load modulation during DR events. It prescribes universal methods to calculate avoided energy consumption, referred to as normalised metered energy consumption, and provides a transparent, replicable, and scalable approach for measuring the impact of DF and energy efficiency interventions.

The framework leverages AMI data and statistical models to deliver the following primary functionalities:

1. **Normalised energy savings calculations**
    - Uses baseline energy models to estimate what energy consumption would have been in the absence of DR interventions.
    - Compares baseline with actual post-intervention consumption to determine savings.
    - Normalises for external factors like weather and occupancy variations.

2. **Time-series energy data processing**
    - Works with hourly, daily, or monthly AMI data and uses statistical techniques to increase accuracy of energy consumption trends.

3. **Automated M&V**
    - Uses real-time, automated calculations and provides a standardised approach for utilities to verify energy savings.

4. **Open-source, transparent methodology**
    - Is available under an open-source licence that enables peer review and validation by third-party organisations.

Case study

Marin Clean Energy (MCE), a clean energy provider in California, uses the FLEXmarket platform to implement a peak shaving DR programme. FLEXmarket, an enterprise-grade solution that consolidates programme data into a unified interface, uses OpenEEmeter to accurately measure the volume of load shed by consumers and compensates them accordingly. In the summer of 2022, Contra Costa County engaged in MCE's programme by shifting AC load in two dozen buildings. Over the course of 11 DR events, aided by accurate M&V through OpenEEmeter, the county earned over $15,000 in incentives and saved $3,000 in energy bills.

Challenges and considerations

Implementation of OpenEEmeter, despite it being an open-source framework that is widely used for M&V in DF programmes, comes with a few hurdles. It:

1. Requires widespread AMI to measure load shed or shift accurately.
2. Requires an entire year's AMI data to calculate baseline energy consumption before it can start accurate M&V of DF interventions.
3. Requires technical expertise and capacity building, including data science and statistical modelling skills, for implementation and maintenance.

Regulatory sandbox

The NGFP will facilitate a controlled environment for testing, evaluating, and refining DF regulations before large-scale implementation. With oversight from regulators, the NGFP will provide the tools necessary for innovators and DISCOMs to trial new policies, services, technologies, or methodologies without requiring adherence to the usual market rules and regulations. It will support diverse pilot programmes to simulate use cases such as load shifting, load modulation, and ancillary services, etc., and provide actionable data for regulators to refine DF policies.

The energy markets regulator in Great Britain, Ofgem, runs an Energy Regulation Sandbox that provides detailed guidelines on eligibility criteria, application requirements, available support, and other pertinent information.[23] The regulatory sandbox envisioned for the NGFP can look to the Ofgem example for insights and best practices.

Features of the NGFP

Complementing its core capabilities, the NGFP will aim to build in the following features to support scalability of DF programmes.

Cybersecurity and data privacy

All DF providers that onboard on the NGFP will be connected to communication and control software and networks. This increase in connection points widens the attack surface that could be exploited by malicious actors. Further, since the NGFP network will be transmitting vast amounts of consumer and DISCOM data, there is a need to engineer robust cybersecurity and data privacy strategies. Adhering to national and international standards, the NGFP will build in strict cybersecurity and data privacy protocols, including end-to-end encryption, role-based data access control, and periodic audits to protect consumer and grid data.

Features including data encrypted with cryptographic signatures, authorised data access, and identity systems will help maintain trust in executing DF transactions.[24] Further, the US Department of Energy's best practices for cybersecurity for DERs and the UL 2941 cybersecurity certification standard for DERs map out hardware and software security requirements and provide useful information for industry stakeholders in India.[25]

Interactive user interface

While each DF provider and buyer will connect to the NGFP network via its own network interface, the NGFP may provide reference applications that include software and a user-friendly interface to quickly integrate on the network. This will be primarily expected to help hesitant DISCOMs integrate DF more smoothly into their daily operations via the NGFP.

Knowledge repository

Finally, the NGFP will serve as a central knowledge repository to assist capacity building and knowledge sharing among consumers, regulators, and DISCOMs. It will host pertinent information, including, but not limited to, a database of DF-ready smart device technologies, cost-effectiveness testing methodologies, DF capacity accreditation techniques, and any public reports on results of regulatory sandboxes.[vi] By making relevant information accessible in one location, the NGFP will aim to accelerate uptake of DF by assisting onboarding of new DISCOMs and regulators.

Value creation by the NGFP

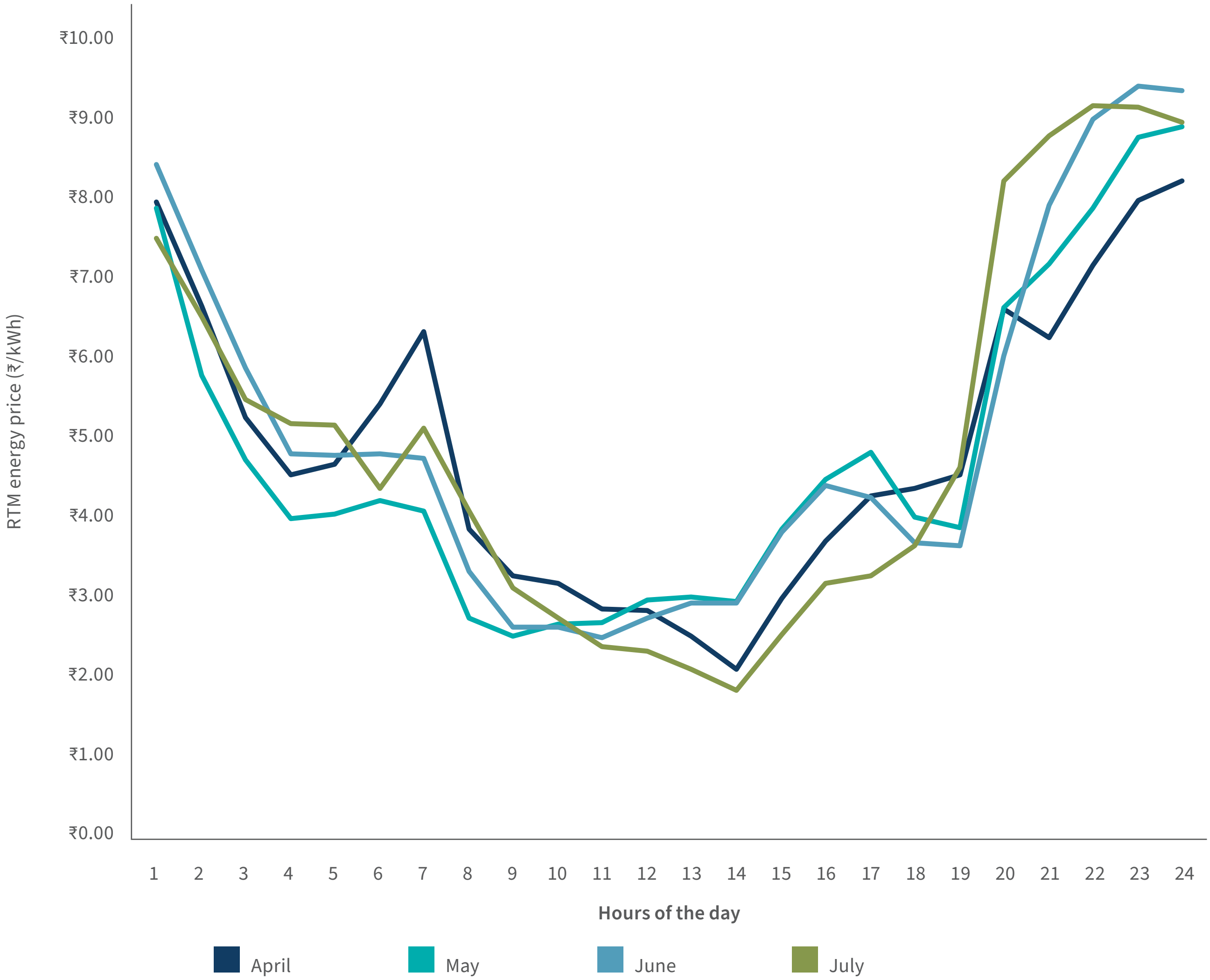
The NGFP will aim to set up a sustainable and scalable DF ecosystem by focussing on an open network-centric model that transcends the traditional piecemeal programmatic-based approach to DF. Its core design principles of decentralisation, interoperability, standardisation, and composability will aim to address the challenges highlighted in Limitations in India's DF efforts section and create value for all ecosystem participants. The sections below present how various stakeholders in the DF ecosystem can benefit by integrating with the NGFP network.

DISCOMs

Successful implementation of large-scale DF promises to capture substantial power procurement savings for Indian DISCOMs. RMI analysis of real-time market (RTM) data on IEX shows that post-solar peak power prices in summer 2024 were up to three to four times higher than daytime prices, forcing DISCOMs to spend a disproportionately higher amount on procuring peak power (**Exhibit 5**).

vi. Capacity accreditation refers to the process of assigning a reliable resource adequacy, or capacity, value reflecting a resource's expected contribution to meeting peak demand during critical grid conditions. It is used to determine a fair and accurate resource adequacy payment for a resource class.

Exhibit 5 Average hourly RTM energy price on IEX for summer months in 2024



RMI Graphic. Source: RMI Analysis of IEX market data

Beyond energy exchange purchases, DISCOMs often rely on costly gas-based generators to meet evening peaks. For instance, even though gas generators provided 10% of the annual energy requirement for BSES in Delhi, they accounted for 20% of its annual power procurement cost.[26]

By simplifying and standardising procurement of DF, the NGFP can unlock the full value potential of DF for DISCOMs. In addition to power purchase cost reductions, the NGFP can generate significant ancillary grid benefits, such as generation and T&D capex deferral, contribution to system reserves, and voltage and frequency regulation.

Further, by enabling discovery and visibility of distributed resources, the NGFP can support despatch and forecasting decisions and enhance load balancing. Finally, SOPs for aggregator onboarding, M&V, and fulfilment and post-fulfilment can reduce implementation costs for DISCOMs, fostering greater trust in DF as a reliable, cost-effective grid resource.

Aggregators

The NGFP will primarily aim to unlock the clustering of DF capacity by operationalising the aggregator model for DF providers. Thanks to universal data formats, standard onboarding and KYC procedures, and transparent verification and settlement processes, the NGFP can ease entry barriers for aggregators. Further, the decentralised and federated governance structure of the NGFP can lower transaction costs, allowing aggregators to focus on building high-value offerings for their customers.

Consumers

The NGFP sets the stage for a range of consumer benefits — both current and future. While the most readily accessible benefit for consumers will be monthly bill savings by participating in aggregator-based DF programmes, the open network model of the NGFP can create pathways for the development of new energy services that conform to the open network protocol.
For example, peer-to-peer energy trading can be integrated on the NGFP network, enabling prosumers (consumers with rooftop solar) to sell their excess power to other consumers on the network. Similarly, DF assets on the NGFP network can be bundled to provide ancillary services in the future, opening up new revenue streams for asset owners.

Recommendations for Scaling the NGFP

Realising the vision of the NGFP to accelerate uptake of DF in India requires concerted and coordinated effort from several stakeholders. This section highlights recommendations that are most critical for kickstarting the NGFP and creating a conducive environment for DF to grow effectively. A brief overview of the recommendations is provided in **Exhibit 6**, and a detailed discussion follows.

Exhibit 6 Summary of recommendations for scaling the NGFP

Recommendation	Description	Key stakeholders	Timeline
Develop enabling regulations	Incentivise integration of DF in day-to-day grid operations (e.g., via DFPO like in Maharashtra).	CERC, SERCs, DISCOMs, academia	1–2 years
	Implement standard cost-benefit analysis (CBA) guidelines.		<1 year
	Support fair, transparent price discovery of DF services (e.g., open auction-based procurement).		1–2 years
Test and establish communication protocol	Implement open communication standards to enable interoperability across DF use cases, providers, and geographies.	IES, DISCOMs, CEA, industry	<1 year
Develop M&V and data privacy frameworks	Develop national protocols for setting baselines, telemetry requirements, performance verification, settlement mechanisms, and data sharing and privacy.	CERC, SERCs, DISCOMs, academia	<1 year
Drive 100% smart meter adoption	Explore pathways to accelerate smart meter adoption (e.g., via public-private partnerships between DISCOMs and would-be aggregators).	SERCs, DISCOMs	1–2 years

Exhibit 6 Summary of recommendations for scaling the NGFP (continued)

Recommendation	Description	Key stakeholders	Timeline
Build stakeholder capacity and awareness	Conduct technical workshops to build expertise for DISCOMs.	CERC, SERCs, DISCOMs, academia, CSO, and industry	Ongoing
	Hold policy roundtables for regulators to develop enabling market structures and regulatory frameworks.		Ongoing
	Increase community engagement through public outreach and consumer education programmes.		1–2 years
	Implement small-scale proof-of-concept projects to refine DF programmes, regulations, and NGFP capabilities.		<1 year
Develop business model for the NGFP	Ensure long-term sustainability of the NGFP via viable business models, (e.g., network fees).	DISCOMs, AIDA, CERC, SERCs, industry	1–2 years
Unlock new revenue streams for DF	Develop participation models for DF in energy and ancillary services.	CERC, SERCs, DISCOMs, industry	1–2 years
	Develop capacity accreditation rules and foster resource adequacy payments for DF.		1–2 years

Note: IES – India Energy Stack; CEA – Central Electricity Authority; CERC – Central Electricity Regulatory Commission; CSO – Civil Society Organisation; SERC – State Electricity Regulatory Commission. RMI Graphic.
Source: RMI Analysis

Develop enabling regulations for market development

Key stakeholders: Central Electricity Regulatory Commission (CERC), state electricity regulatory commissions (SERCs), DISCOMs, academia

Despite favourable modelling results and fruitful real-world examples, DF has been underemphasised as a cost-effective grid resource by regulators in India. Consequently, with no SOPs in place for evaluating DF programmes, regulatory approvals have been cumbersome to acquire. Part of the problem lies in a lack of trust in the value and reliability of DF due to a dearth of actionable data and visibility into the grid benefits of DF. With the NGFP aiming to solve for discovery of DF, including visibility into location, capacity, and operation of assets, regulators must establish regulations that can leverage the NGFP network's capabilities to support DF.

Incentivise integration of DF in grid operations

Operational and locational data of flexible capacity available via the NGFP will support smoother integration of DF in grid operations. Central and state regulators can implement regulations that incentivise DISCOMs and load despatch centres to use this data and incorporate DF in day-to-day planning and operations. For example, DFPO regulations established in Maharashtra require that DF capacity must account for a certain percentage of peak load, thus setting a clear DF mandate for state DISCOMs (see **Exhibit 3**, page 20). Other regulatory interventions that reward DISCOMs for implementing DF, or impose penalties for failing to do so, can nudge DISCOMs to adopt DF on a larger scale.

Implement standardised CBA guidelines

To support DISCOMs in evaluating DF programmes systematically, regulators can adopt standardised guidelines of CBA. These methodologies will enable structured, transparent assessments of DF deployment, ensuring well-informed decision-making. Maharashtra can again serve as a blueprint, having prescribed these methodologies in their recent regulations (see **Exhibit 3**, page 20). Approaches will include CBA tests that compare traditional costs and benefits of DF deployment versus traditional grid expansion as well as broader benefits such as network upgrade capex deferral. Some globally accepted tests are listed below:

a. **Total resource cost (TRC) test:** evaluating net costs and benefits from both DISCOM and consumer perspectives.

b. **Participant cost test:** assessing the direct financial impact on consumers who adopt DF measures.

c. **Ratepayer impact measure test:** measuring the effect of DF adoption on overall electricity rates.

d. **Programme administrator cost test:** analysing costs from the perspective of DISCOMs to determine economic feasibility.

e. **Societal cost test:** considering broader economic and environmental benefits, such as emission reductions and reduced grid congestion.

Support transparent price discovery

While it is possible for buyers to procure DF through bespoke bilateral contracts in the initial stages, an important capability envisioned for the NGFP is to enable quick, transparent, and just compensation for DF services via an open transactions protocol. This will involve laying out processes for determining the value of DF services, including standardised CBA guidelines mentioned earlier, and establishing clear rules for buyers to procure DF via the NGFP when they most need it. For instance, the pay-as-bid auction model that matches DF bids with buyer requirements through a competitive auction (see **Box 3**, page 32) is one such price discovery mechanism that can be implemented transparently using the NGFP network's built-in immutable ledger. Regulators, potential buyers (e.g., DISCOMs), and academia can deliberate the requirements and pathways for enabling such price discovery of DF via the NGFP.

Test and establish communication standards for interoperability

Key stakeholders: IES, DISCOMs, Central Electricity Authority (CEA), industry

Delivering DF services requires a bi-directional flow of data between buyers and providers that necessitates a two-way application protocol. Given the nascency of DF in India, there is a need to test and establish communication standards that enable seamless interactions between providers and buyers via the NGFP. Such a standard will enable interoperability across buyers, geographies, and DF use-cases and support real-time telemetry to trigger load adjustments based on grid needs.

Stakeholders can use the regulatory sandbox capability to test and refine communication protocols. The controlled environment of a sandbox can provide insightful data and help integrate learnings and best practices before wider rollout. Global standards like OpenADR and IEC 61850 (adopted by the United States, the EU, and Australia) can be assessed for applicability in India and compliance with CEA's smart metering framework. Beckn Protocol, an indigenous open-source protocol that powers UEI, an open network, can be trialled via the NGFP to provide a homegrown solution to interoperability of DERs and DF assets.

Establish a framework for M&V, data security, and consumer privacy

Key stakeholders: CERC, SERCs, DISCOMs, academia

For DF programmes to effectively deliver value for buyers and providers, a robust M&V framework can ensure that DF interventions provide measurable and reliable grid flexibility services. M&V frameworks help establish a clear and transparent baseline methodology to measure the quantum of demand reduction during DF despatch. Some global best practices for establishing standardised M&V methodologies include an ex-post and ex-ante baseline methodology established in Australia that uses 10-day historical averages and verifies demand adjustments using smart meter data. Real-time measurement of DF can be implemented by requiring market players (e.g., aggregators) to provide live telemetry data. Aggregators in the UK are expected to submit real-time DR event data to the NESO for settlement. Standardised performance reporting and third-party audits can prevent gaming or misreporting of devices participating in DF programmes. Finally, it is of utmost importance to develop automatic settlement mechanisms where verified demand adjustments are compensated based on performance. For example, the New York Independent System Operator uses automated settlement software to compensate DF providers based on verified DR events.

Developing a national methodology and processes for setting baselines, telemetry standards, settlement mechanisms, audit processes, and M&V and reporting guidelines will help stakeholders design effective and accurate DF programmes.

In parallel, there is also a need to develop cybersecurity protocols, data encryption, and access controls to protect consumer energy data. Unlocking access to energy use data in real time for market participants while ensuring compliance with India's Digital Personal Data Protection (2023) will be crucial. Regulators can look to global best practices like the Green Button Initiative in the United States that standardised a secure data-sharing format and allowed consumers to access and share their electricity usage data with aggregators. Denmark's Energy Data Hub offers valuable lessons for enabling secure data sharing between grid operators, consumers, and DISCOMs.

Drive AMI deployment

Key stakeholders: SERCs, DISCOMs

Despite a significant push by the Central Government to roll out 25 crore smart meters, or AMI, across India by 2027, progress has been slow, with less than 2.2 crore smart meters installed as of February 2025. As smart meters are critical for accurate M&V and quick, transparent settlement for DF programmes, the true potential of the NGFP will materialise on the foundation of a rapid smart meter rollout.

A rapid smart meter rollout benefits DISCOMs by improving billing efficiency, thereby reducing the aggregate technical and commercial losses, and offers them potential financial benefits by monetising aggregated, anonymised energy data for network planning, new load management (EVs, E-buses), and smart grid optimisation via third-party service providers. Benefits can be extended to consumers, as insights from smart meter data can help them optimise energy use, nudge them towards energy-efficient behaviours, and facilitate transparent, automated transactions for DF services or rooftop solar generation.

DISCOMs and state regulators can explore innovative models to drive adoption. For instance, subscription-based models where consumers pay a fixed monthly fee for smart metering and energy management services can help cash-strapped DISCOMs. Similarly, partnerships between DISCOMs and would-be DF providers can help them share costs, expertise, and responsibilities in installing smart meters.

Build stakeholder capacity and awareness

Key stakeholders: DISCOMs, CERC, SERCs, civil society organisations (CSOs), academia, and industry

To support the successful adoption of DF within the power sector, a series of comprehensive training programmes and knowledge-sharing initiatives can be developed and delivered to stakeholders, including DISCOMs, regulatory bodies, and consumers. These efforts aim to address barriers to DF adoption, particularly inadequate customer engagement identified in earlier sections, by increasing awareness, enhancing technical capacity, and promoting a collaborative, customer-centric approach to DF integration. Empowering all relevant parties with the right knowledge and tools will help strengthen the foundation for DF adoption, ensuring that its benefits are fully realised across the grid ecosystem. Some potential initiatives are highlighted below.

Technical workshops for DISCOMs

A series of training workshops can be organised for DISCOMs, focussing on the value of aggregator-based DF, accurate estimation of costs and benefits, and the integration of the NGFP and DF strategies into operational processes. Participants will gain expertise in using the NGFP network to incorporate DF, equipping them to balance supply and demand effectively while minimising operational costs and enhancing grid stability.

Policy roundtables with regulators

Collaborative policy discussions can be facilitated through roundtables involving regulatory authorities, market operators, and industry stakeholders. These discussions can focus on aligning market structures and regulatory frameworks with the evolving objectives of DF, addressing issues such as incentive structures, grid reliability, and cost-sharing mechanisms. The goal should be to create a unified regulatory approach that fosters the integration of DF into market operations through the NGFP, ensuring it is both incentivised and scalable within the broader energy landscape.

Consumer education programmes

Engaging consumers in public outreach efforts can educate them on the financial and environmental benefits of engaging in DF initiatives. Tailored educational campaigns can inform households and businesses about the potential for cost savings and highlight the role they can play to support grid efficiency and reduce associated emissions. These programmes should include various media platforms, including online tutorials, informational brochures, and community workshops, to reach a diverse audience and encourage active participation in DF programmes.

Proof-of-concept demonstration projects

Designing and implementing small-scale demonstration projects through the regulatory sandbox capability of the NGFP can test the technical feasibility, economic advantages, and reliability of DF interventions under real-world conditions. Results from these projects can provide an opportunity to refine programme design and ensure implementation of DF via the NGFP is viable before broader deployment.

A key focus area should be the demonstration of aggregator-based DF models. By leveraging the regulatory sandbox capability, pilot programmes can test and refine aggregation models, demonstrating their effectiveness in improving grid flexibility. Further, these pilot projects should be implemented across multiple sectors and end-use cases, including residential, commercial, and industrial. This sector-specific approach will highlight adaptability across diverse consumer categories and generate valuable insights into energy consumption patterns, response behaviours, and the potential for scalable DF solutions.

Develop sustainable business models for the NGFP

Key stakeholders: DISCOMs, AIDA, CERC, SERCs industry

Once the NGFP network is live and has successfully facilitated a demonstration DF project, the next step would be to develop a viable, long-term revenue model and establish a credible anchor agency for oversight and upkeep. While the NGFP network is envisioned to be low-cost and asset-light, its oversight entity will require funding for infrastructure maintenance and integration of buyers and providers. Stakeholders can organise roundtables with industry and government participants to brainstorm sustainable revenue models for long-term viability of the NGFP. Examples include technical integration fees for onboarding new participants, nominal subscription or transaction fees, or cross-subsidisation by the oversight entity through revenues from other sources. Ultimately, the NGFP should aim to charge minimal fees to participants and yet generate enough revenue to remain viable.

Unlock new revenue streams for DF

Key stakeholders: CERC, SERCs, DISCOMs, industry

While robust CBA methods and transparent price discovery models will help ensure fair compensation for the array of grid services provided by DF, regulators can aim for full participation of DF in electricity markets to unlock maximum revenue opportunities. An important step in this direction would be formulating regulations that introduce aggregators as new market participants that bid pooled DF assets as one resource in the electricity markets. For instance, the Australian Energy Market Commission updated its National Electricity Rules to enable wholesale DR by creating a new market participant category: DR service providers, who are settled in the wholesale market like other market participants.[27]

Globally, market structures, including resource adequacy, or capacity markets, ancillary services markets, and energy markets, provide crucial value-stacking potential for DF providers. In the United States, Federal Electricity Regulatory Commission (FERC) Order 2222 directed system operators (SOs) to incorporate aggregations of DERs (including DF resources) fully into the wholesale markets (see **Box 3**, page 32). This implies creating new market participation rules for aggregations, updating scheduling and despatch software, and developing verifiable settlement mechanisms. In Texas, which is outside FERC's jurisdiction and, thus, exempt from Order 2222, the market operator, Electricity Reliability Council of Texas (ERCOT), is pursuing its own open market participation regulations for DER aggregations. With a pilot currently under implementation, ERCOT has registered 80 MW of aggregated fast-response (within seconds) DERs to provide fast frequency response and operating reserves services.[28]

Indian regulators can look to FERC's and ERCOT's regulations to enable DER and DF aggregations to participate in the energy exchanges. Developing market participation models for DF in the energy market and Ancillary Services Mechanism while expanding the Ancillary Services Framework (CERC 2022) can incentivise fast-response DER and DF resources like battery storage, industrial loads, and EV charging and battery swap stations to provide real-time flexibility. Similarly, introducing a performance-based capacity accreditation mechanism, defined under the Ministry of Power's Resource Adequacy Planning Framework, can ensure DERs and DF are fairly compensated for contributing to resource adequacy.[29] Opening up the electricity markets to DER and DF participation can significantly improve the financial proposition for aggregators while enhancing grid reliability and reducing system costs.

Conclusion

As India continues its journey towards a more resilient, sustainable, and efficient power system, DF can play a central role in balancing the grid, integrating renewable energy, and reducing costs
for both DISCOMs and consumers. The lessons learned from both global and Indian experiences underscore the immense potential of DF when supported by robust regulatory frameworks, advanced digital platforms, and active stakeholder engagement.

The proposed NGFP provides a transformative opportunity to scale DF across the country and demonstrate the potential of power sector digitalisation. By fostering standardisation, enabling aggregator models, and ensuring seamless interoperability, the NGFP can unlock gigawatt-scale flexibility and drive a paradigm shift in India's electricity sector. Establishing clear regulatory frameworks, including CBA guidelines, robust M&V methodologies, rapid deployment of smart meters, and the creation and dissemination of financial incentives to encourage widespread participation from consumers, providers, and buyers will ensure its success.

Additionally, overcoming existing barriers to adoption will rely on strong collaboration among regulators, DISCOMs, technology providers, and industry stakeholders. The development of a regulatory sandbox within the NGFP will allow for controlled experimentation, ensuring that policies and market structures evolve in alignment with technological advancements and real-world applications. Moreover, the NGFP is aligned with the vision of the emerging IES. Built on the same core design principles — including open registries, interoperable APIs, and data consent frameworks — it complements the IES.

With soaring peak demand, rising renewable penetration, and the urgency of decarbonisation, India must act decisively to integrate DF into its energy planning and operations. The NGFP serves as a starting point for this transformation, providing the digital infrastructure and market mechanisms necessary to make DF a cornerstone of India's modern energy ecosystem.

By embracing this vision and taking concrete steps towards implementation, India can lead the way in demonstrating how digital innovation and regulatory foresight can redefine power system resilience, affordability, and sustainability. The time for action is now, and the successful realisation of the NGFP's vision will set a benchmark for the world in integrating DF at scale.

Appendices

Appendix A: Piclo Flex

Piclo Flex is a cloud-based, end-to-end marketplace-as-a-service platform designed to facilitate the procurement and operation of local grid flexibility services.[30] It provides a digital infrastructure layer that connects demand flexibility (DF) buyers — system operators (SOs) such as grid operators and utilities — with DF sellers, flexibility service providers (FSPs) such as DER and DF aggregators, energy retailers, and asset managers. By streamlining the process of flexibility procurement, operation, and settlement, Piclo Flex supports smooth integration of DF in day-to-day grid operations and enhances reliability. The marketplace currently operates in six global markets: Australia, Ireland, Italy, Portugal, the United Kingdom, and the United States. As of January 2025, it had over 3.5 lakh registered flexible assets representing more than 26 gigawatts (GW) of capacity, with flexibility contracts awarded totalling £75 million and more than 3 GW.

By building a marketplace that is technology-agnostic and accessible to DERs, DF assets, aggregators, and other market participants, Piclo Flex presents a model case study for the National Grid Flexibility Platform envisioned for India in this paper. Designed for use by SOs, a main feature of Piclo Flex is transparent "flexibility competitions" in which SOs advertise their flexibility needs and FSPs submit bids. The marketplace comprises modular components that SOs can select based on their specific flexibility and process automation needs. Subscription fees are dependent on the SO's selections. The modules are:

a. **Procurement:** This phase allows SOs to define flexibility needs, launch competitions, and assess asset and FSP eligibility through a robust qualification framework. FSPs can respond to these competitions by submitting bids, which are evaluated based on a range of criteria, including location, capacity, and price.

b. **Operations:** Once bids are accepted and contracts awarded, this module supports the operational phase of flexibility delivery. This includes real-time visibility into asset availability, despatch notifications sent via secure channels, and acknowledgement protocols to confirm successful activation.

c. Settlement: The post-despatch settlement module relies on a robust measurement and verification framework. Contracted expectations of performance are assessed against meter data, baseline load profiles, and despatch records to generate auditable and automated payment invoices. Detailed reporting features simplify regulatory compliance and financial settlement.

d. Exchange: This module is a secondary trading marketplace that allows users to buy and sell existing flexibility contracts. This feature enhances market liquidity and asset utilisation, enabling Piclo Flex to move beyond static procurement models to a more dynamic flexibility marketplace.

At the heart of Piclo Flex's capabilities is a robust communication protocol built on the OpenAPI specifications. These specifications are a standardised way to describe the platform's "RESTful" APIs that allow easy integration with advanced distribution management systems, DER management systems, and other back-end systems to ensure smooth, automated communication between SOs and FSPs.[vii] These open APIs support procurement, operations, and settlement processes, enabling streamlined qualification, bidding, despatch communication, and invoicing.

Piclo Flex employs enhanced data security measures to safeguard SO and FSP data. It is hosted on Amazon Web Services, leveraging its security features, and data is encrypted both in transit and at rest using industry-standard encryption ciphers. The platform's parent company, Piclo, is ISO 27001 certified, an international standard for information security management systems.

The capabilities of Piclo Flex closely mirror the envisioned architecture of the NGFP, making it a valuable model for operationalising aggregator-based DF at scale. Piclo Flex's modular design — including procurement auctions, real-time operational coordination, automated settlement, and robust APIs — demonstrates how digital infrastructure can bridge SOs and FSPs without compromising data security or market integrity. Its deployment across geographies and grid use cases illustrates the feasibility of an independent, standardised marketplace that supports both local system needs and broader grid balancing. As India develops its own NGFP, the functional architecture and learnings from Piclo Flex can offer critical insights into building a trusted, scalable, and technology-driven ecosystem for DF.

vii. RESTful APIs are a type of web API that conforms to the principles of representational state transfer (REST) architecture, enabling systems to communicate over the HTTP protocol in a standardised and scalable way. REST is a set of constraints and guidelines for building APIs that are widely supported by web-based platforms and tools.

Appendix B: Digital Energy Grid

Digital Energy Grid (DEG) is a foundational digital infrastructure that seeks to bridge the gap between energy flows, information flows, and transaction flows in the energy ecosystem. It offers a universal, interoperable framework that enables seamless coordination between energy assets, actors, and transactions. Inspired by the open architecture of the internet and unified systems like the Unified Payments Interface (UPI) in India, DEG proposes a shared, programmable, and scalable digital backbone for the energy ecosystem.

A key function of DEG is to function as a "network of networks," unifying DERs, Internet-of-Things (IoT) devices, and energy infrastructures across geographies. By incorporating interoperability as a core principle, employing a modular, scalable architecture, and adopting open standards and protocols, DEG is designed to facilitate seamless interaction between diverse energy systems and actors. The primary building blocks of DEG are:

a. Universal and interoperable digital identity for all energy assets and actors — much like a phone number or IP address — ensuring addressability and traceability across the system.

b. Machine-readable data formats to ensure metadata is standardised and processable systematically by software.

c. Verifiability of data using cryptographic tools that uphold data sovereignty, enabling all records — energy flows, transactions, certification — are encrypted, privacy-preserving, and portable across the entire ecosystem.

DEG offers a vision where a "digital grid" augments the physical energy grid, complementing existing systems, bridging legacy standards while enabling future innovation. Crucially, it holds remarkable promise for the NGFP by providing the digital infrastructure necessary to operationalise aggregator-based DF at population scale. Its core tenets of universality, interoperability, and verifiability resonate with the NGFP's vision, thus creating a strong foundation for the NGFP to scale DF as a mainstream grid resource.

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