Innovative Demand Response Resource Development Technology using Data Center

Grid-Interactive Data Centers, A New Approach to Power System Flexibility

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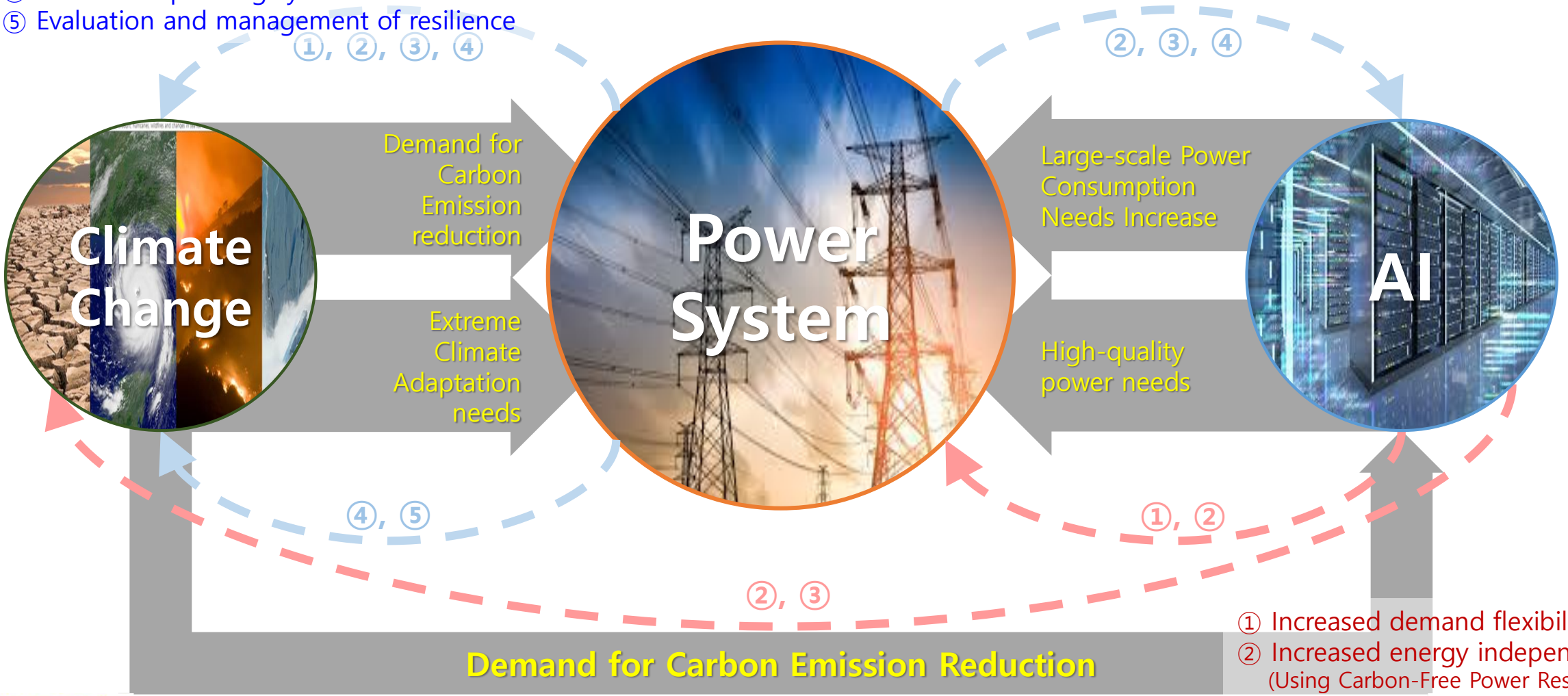
Building a Resilient Future - The Imperative of Cross-Industry Environmental Collaboration

① increase in carbon-free power generation resources
② expansion of transmission networks
③ Increasing Flexible Resources
④ advanced operating system
⑤ Evaluation and management of resilience



① Increased demand flexibility
② Increased energy independence
(Using Carbon-Free Power Resources)
③ Energy efficiency improvement

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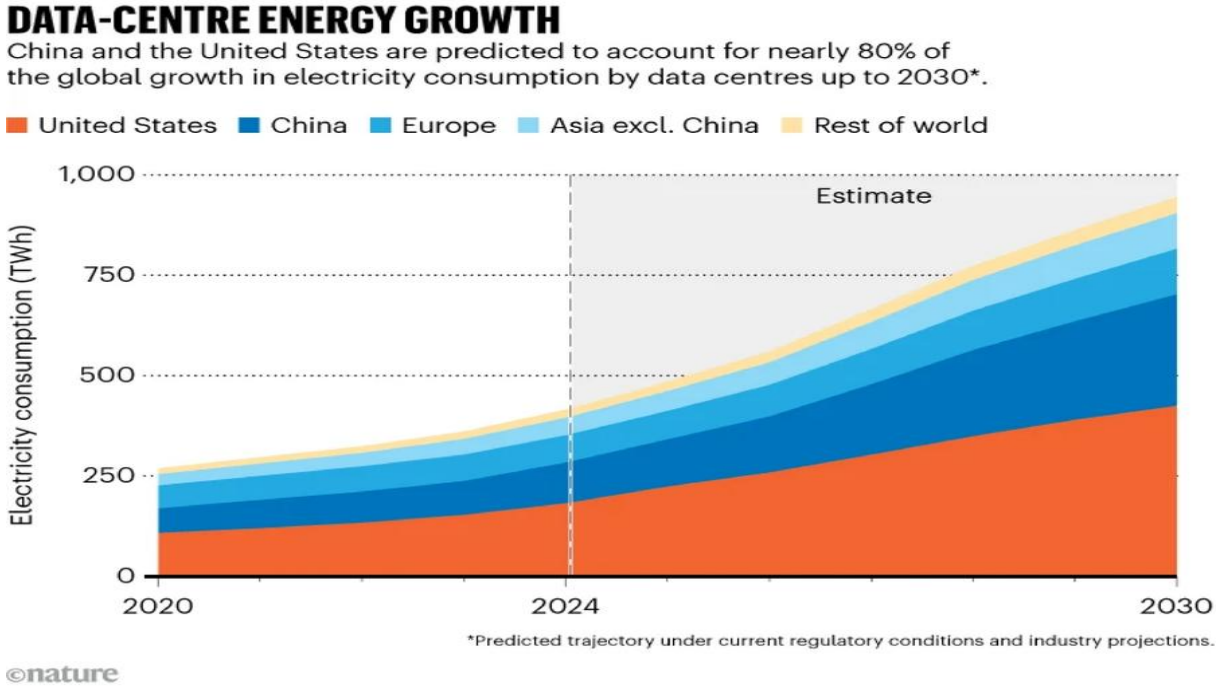
1. The Need and the Potential of Data Centers as a Flexible Grid Resource

The Need and the Potential of Data Centers as a Flexible Grid Resource

Global Data Center Trends

Amidst the projected surge in data centers, particularly in the U.S. and China, a corresponding sharp rise in energy consumption is also anticipated.

According to EPRI (Electric Power Research Institute), U.S. data center electricity consumption is projected to grow by an average of 3.7% to a maximum of 15% annually by 2030.



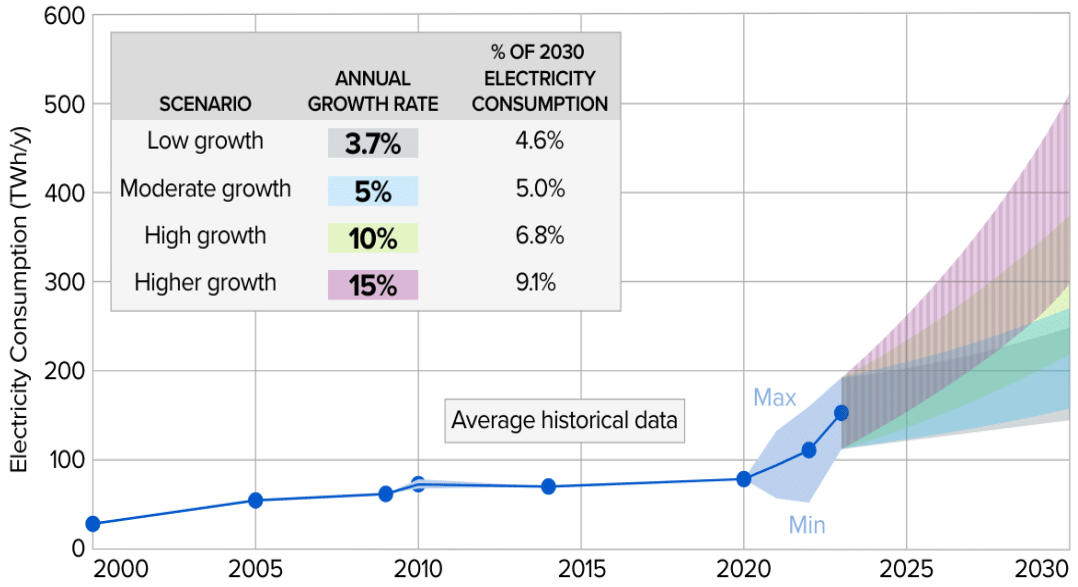


Figure ES-1. *Projections of potential electricity consumption by U.S. data centers: 2023–2030 . % of 2030 electricity consumption projections assume that all other (non-data center) load increases at 1% annually.*

The Need and the Potential of Data Centers as a Flexible Grid Resource

Global Data Center Trends

The U.S. "AI Action Plan" (effective July 23, 2025) is structured around three core pillars: (1) innovation through regulatory reform, (2) AI infrastructure, and (3) AI diplomacy and security.

경제 : 경제일반

미국의 변심 "칩 제조보다 AI 인프라 확보"… 한국에 기회?

중앙일보 | 입력 2025.07.28 00:01 지면보기

심서현 기자 구독

미 반도체정책 지각변동

이중 '인프라' 장에는 반도체 공장과 데이터센터, 전력 발전소 등 AI 인프라를 빠르게 건설할 수 있도록 환경 허가와 규제를 확실하게 풀겠다는 선언이 담겼다. 특히 'AI 혁신에 부합하는 전력망 구축'을 별도로 언급했다. 이를 위한 정책으로는 ▶전력망 최적화·효율화 기술을 개발하고, ▶지열·핵분열·핵융합 등 새로운 에너지 발전 기술을 적극 도입하겠다고 했다.

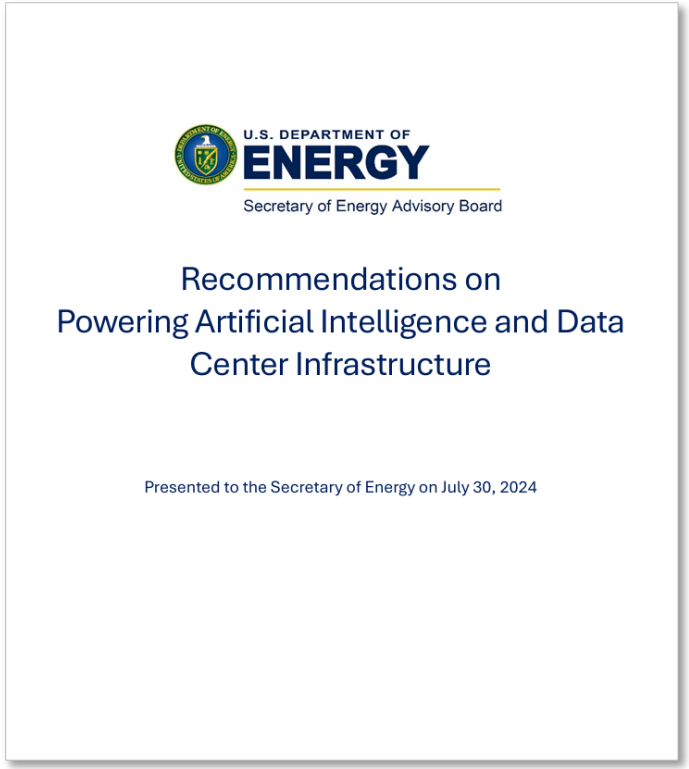
도널드 트럼프 미국 대통령이 23일 열린 'AI 경쟁 써밋'에서 AI 인프라 안보를 강화하는 내용의 행정명령(AI 행동 계획)에 서명한 뒤 들어보이고 있다. [AP=연합뉴스]

트럼프 대통령이 협력 파트너로 소개한 젠슨 황 엔비디아 최고경영자(CEO)가 객석을 향해 손을 들며 인사하고 있다. [AFP=연합뉴스]

The Need and the Potential of Data Centers as a Flexible Grid Resource

US, DOE Powering AI & Data Center Infrastructure W/G Report

DOE Announces "Policy Recommendation on Artificial Intelligence and Data Center Infrastructure Power Supply (2024.07)" as Working Group Results


U.S. DEPARTMENT OF ENERGY
Secretary of Energy Advisory Board

Recommendations on
Powering Artificial Intelligence and Data Center Infrastructure

Presented to the Secretary of Energy on July 30, 2024

Track 1: Maximizing Energy Efficiency for AI Model Training and Inference in Large-Scale Data Centers
Uncertainty in demand forecasting. Spatial and temporal flexibility in AI training and inference. Public-private R&D collaboration strategies.

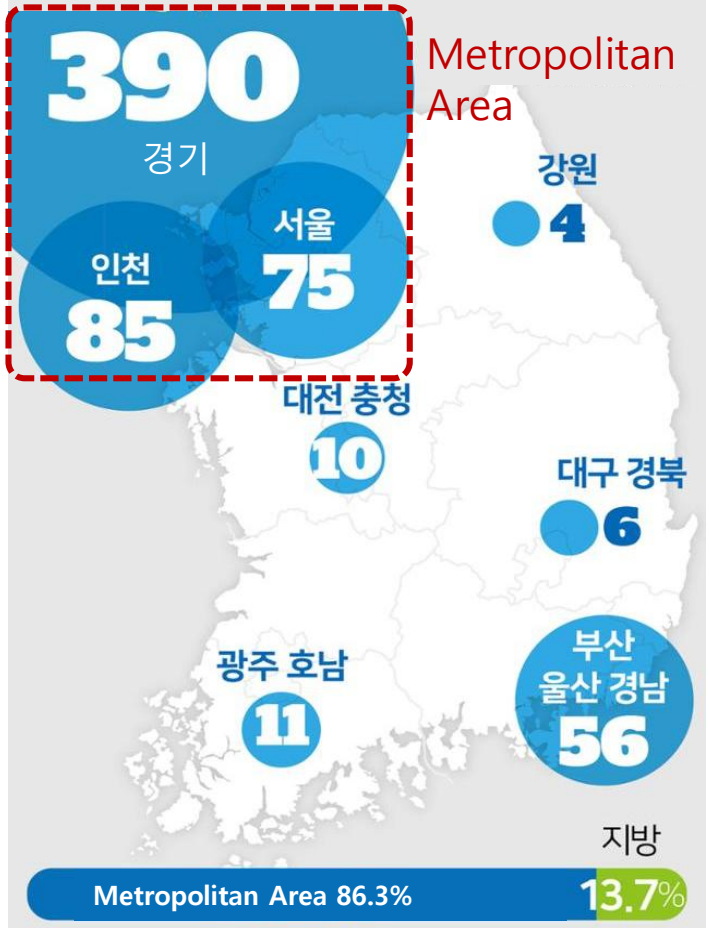
Track 2: Optimizing Data Center Power Consumption and Enhancing Grid Support Functions
Solutions for transmission congestion relief. Establishment of a data center flexibility framework. Innovation in backup power systems and policy support.

Track 3: Advancing Generation, Energy Storage, and T&D Technologies for Data Centers
Improvements in power backup technologies (e.g., UPS). Enhancements in renewable and next-generation power generation technologies. Expansion of transmission and distribution grids.

The Need and the Potential of Data Centers as a Flexible Grid Resource

Grid impact due to concentration of data centers in Seoul metropolitan area

Number of regional data center project through 2029



1. **Reduction of electrical grid stability margin due to increased power flow to metropolitan area.**

Grid Issue

2. Increase the risk of national disasters in the event of an accident in a centralized area of data centers in the metropolitan area.

3. Imbalance in regional economic development.

The Need and the Potential of Data Centers as a Flexible Grid Resource

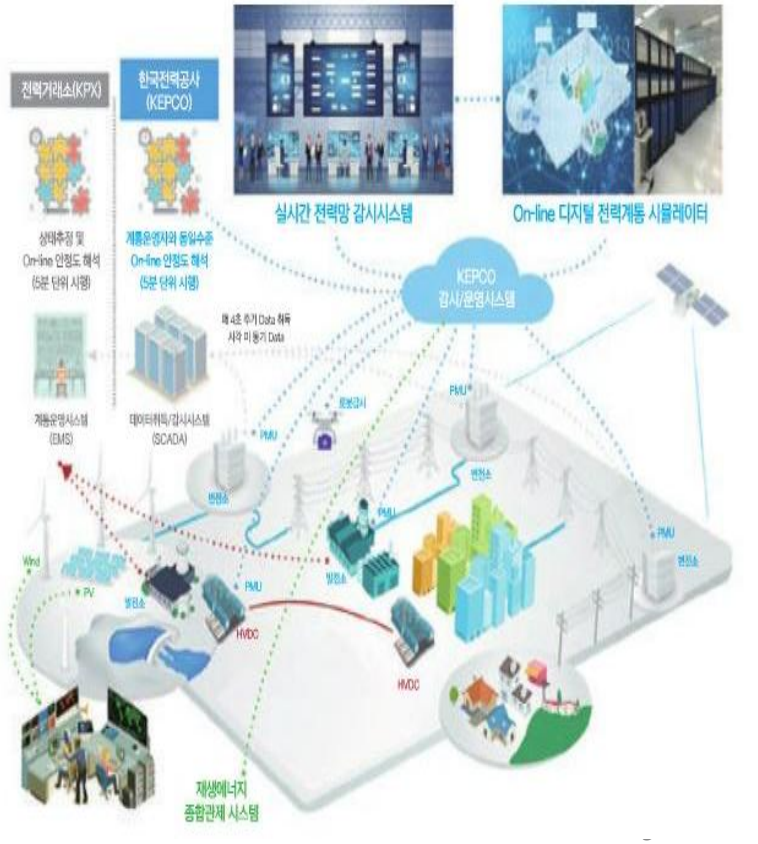
Technical alternatives that can be considered for resolving power grid issues

Power Grid Expansion

Flexible Resource Development

- 의무감축 DR
  - 표준 DR
  - 중소형 DR
  - 국민 DR
- 자발적감축 DR
  - 경제성 DR
  - 미세먼지 DR
  - 피크수요 DR
- 주파수연계감축 DR
  - Fast DR
- 수요증대 DR
  - Plus DR
  - (2024년 육지시장 확대)

Optimum Operation



The Need and the Potential of Data Centers as a Flexible Grid Resource

Definition and distinction of power grid flexibility

Achieving an effective balance between electricity supply and demand is a critical capability. It's essential not just during normal operations, but also during unexpected shifts in demand, power generation changes, or grid failures.

- **Supply-side Flexibility** refers to the ability to provide flexibility through the start-up and shutdown of generators, output adjustments, and the supply of reactive power.
- **Grid Flexibility** involves providing flexibility by implementing direct current (DC) transmission, adding compensation equipment such as FACTS, or optimizing the grid's topology.
- **Demand-side Flexibility** offers flexibility by responding to grid needs with demand response, which includes either curtailing or increasing consumption.

2. Flexible Resource Technology Integrating Carbon-free Energy Sources and Data Centers

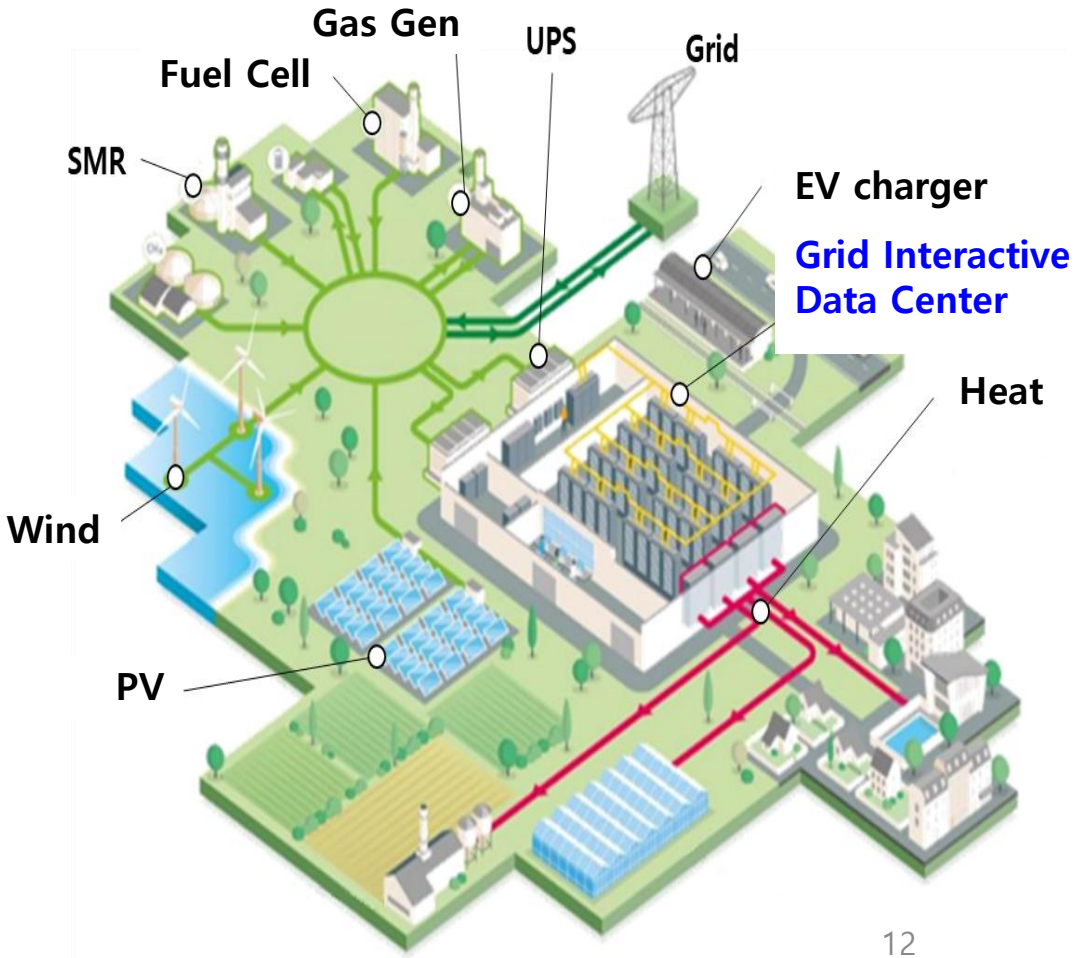
Flexible Resource Tech Integrating Carbon-free Energy Sources & DC

Concept

Integrated power consumption/production system with energy production, consumption, storage, and management centered on AI data centers and carbon-free distributed power sources.
It was named Smarter Power Village(SPV).

Key Tech

A mechanism to design AI data centers so that their computational loads are adjusted in response to power grid conditions, to control the data center UPS, ESS and emergency power in a grid-interactive manner, and to integrate and utilize distributed energy resources (DERs) as flexibility assets for the power system.

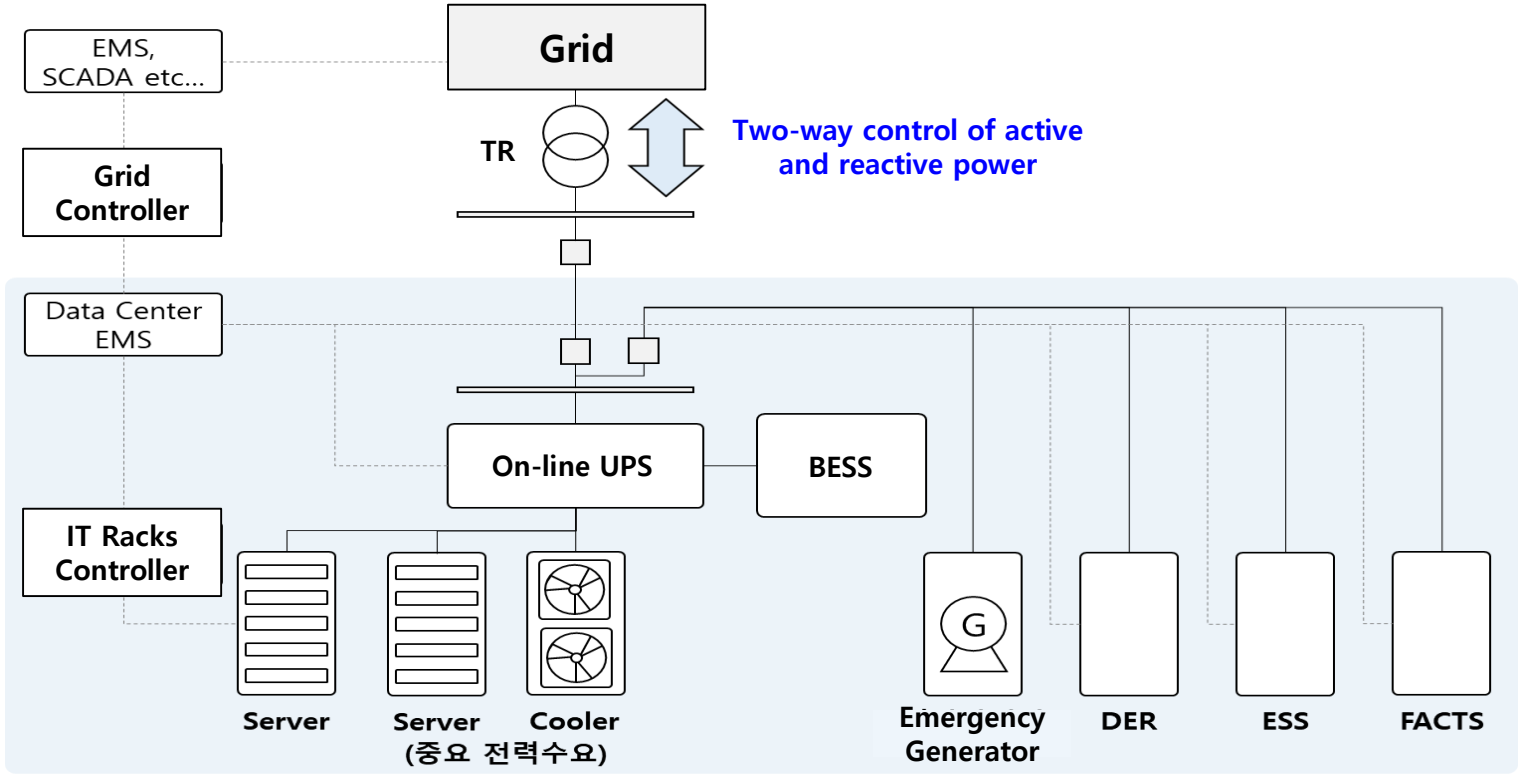


Flexible Resource Tech Integrating Carbon-free Energy Sources & DC

System Configuration Examples for SPV

Building DER, ESS, FACTS with Grid Interactive DC and integrated operation by Data Center EMS

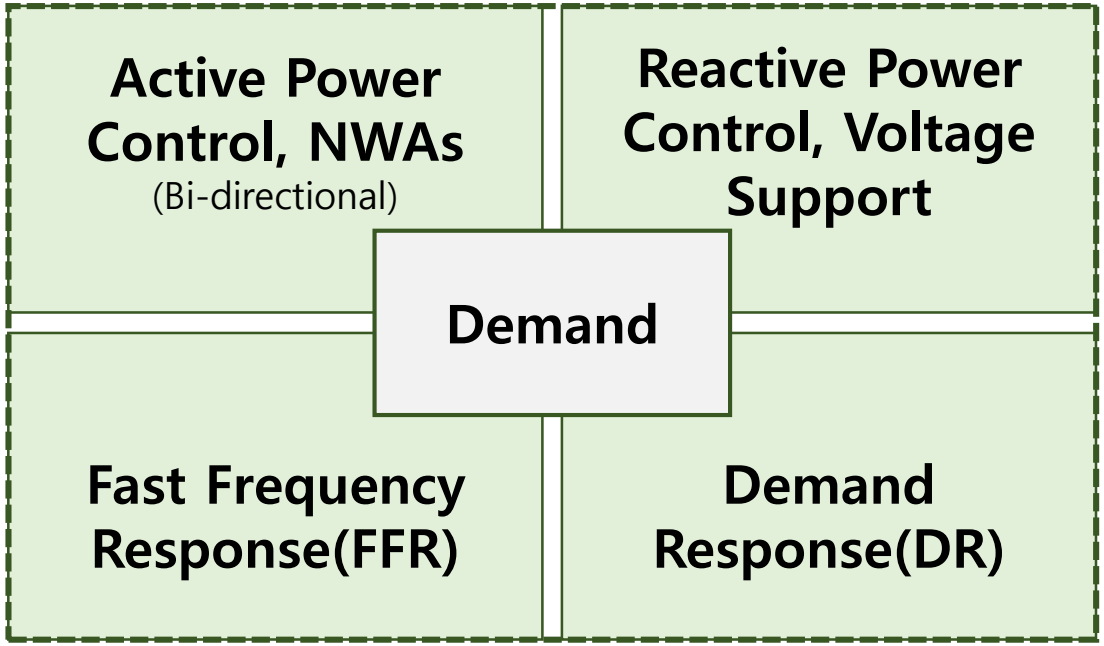
Install grid controller for linking grid operating systems (EMS, SCADA, etc.) to Data Center EMS



Flexible Resource Tech Integrating Carbon-free Energy Sources & DC

Example of a Grid Service on an SPV

The SPV can provide a variety of services to the power grid because it is free to control the active and reactive power between the SPV and the power grid.



[Example of grid service using SPV]

Technical Benefits of SPV

Power Utility's Perspective

: Stabilizing and Flexibilizing the Power Grid, Improving Customer Connectivity, and using as NWAs(Non-Wire Alternatives)

Data center owner's perspective

: Rapid Grid Connection and Stable Power Use

3. KEPCO R&D for SPV

KEPCO R&D for SPV

Phased Development and Demonstration Plan

We're currently conducting a basic feasibility study. Our future plan is to develop and demonstrate flexible resource technologies using data centers, after which we will proceed with the R&D and demonstration for SPV deployment.

Feasibility study (~'25.10)

- Analysis of Data Center Power Facility Characteristics for Flexible Resource Utilization
- Technical Impact Analysis of Data Center Flexible Resources (EMT simulation & Real data center on-line UPS testing, etc.)
- Incentive Program Design for Data Center Flexible Resources

Step 1 (FFR, '26~)

- Development of FFR Operation Technology Using Data Center Online UPS
- Application and Demonstration of FFR Technology to Actual Data Centers
- Incentive Program Propose for Data Center Flexible Resources

Step 2 (SPV)

- Development of Core Technologies for SPV Deployment
- Implementation of a pilot project for SPV technical verification

Thank you for your attention!