Combined Heat & Power Microgrids Resiliency And Reliability

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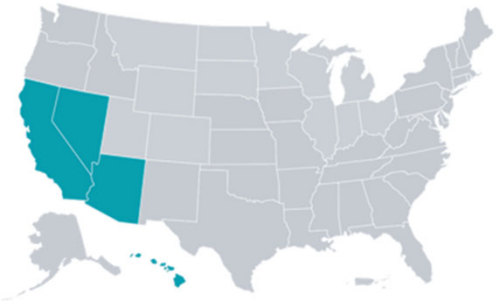
WESTERN

CHP
TECHNICAL ASSISTANCE
PARTNERSHIPS



U.S. DEPARTMENT OF ENERGY
CHP Technical Assistance Partnerships
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U.S. DOE CHP Deployment Program Mission & Scope

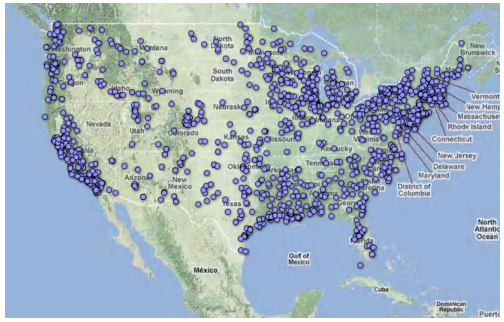
Mission

- Provide stakeholders with the resources necessary to identify CHP market opportunities

  Support implementation of cost-effective CHP systems in industrial, commercial, institutional, and other applications

Scope

- CHP Market and Project Resources
- Packaged CHP eCatalog
- Packaged CHP Accelerator
- CHP Technical Assistance Partnerships (CHP TAPs)



energy.gov/chp

U.S. DOE CHP Deployment Program Mission & Scope

End User Engagement

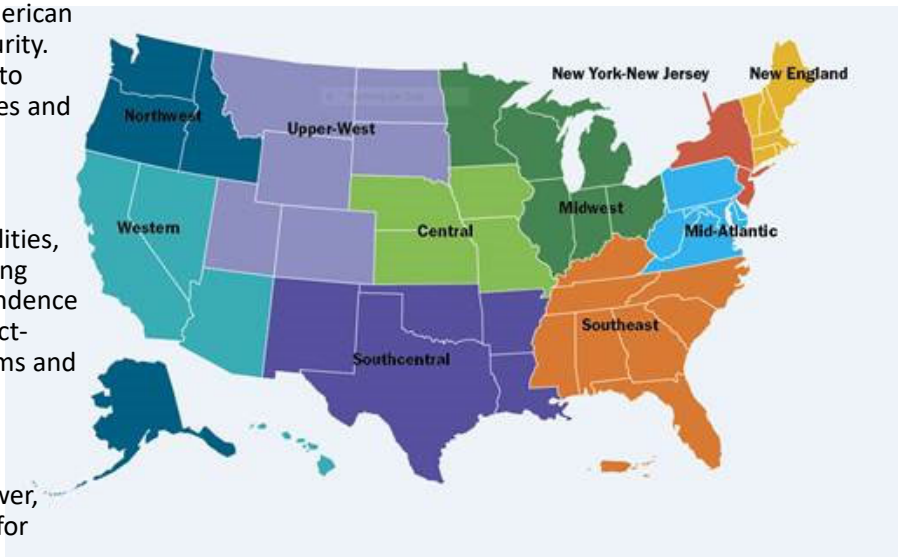
Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.

Stakeholder Engagement

Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.

Technical Services

As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.



www.energy.gov/chp

Defining Terms

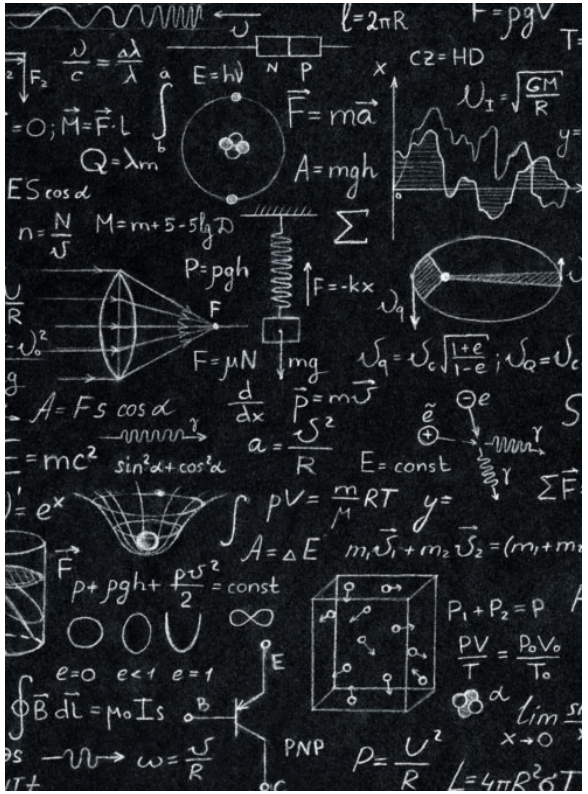
Combined Heat & Power (CHP)

The concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy.

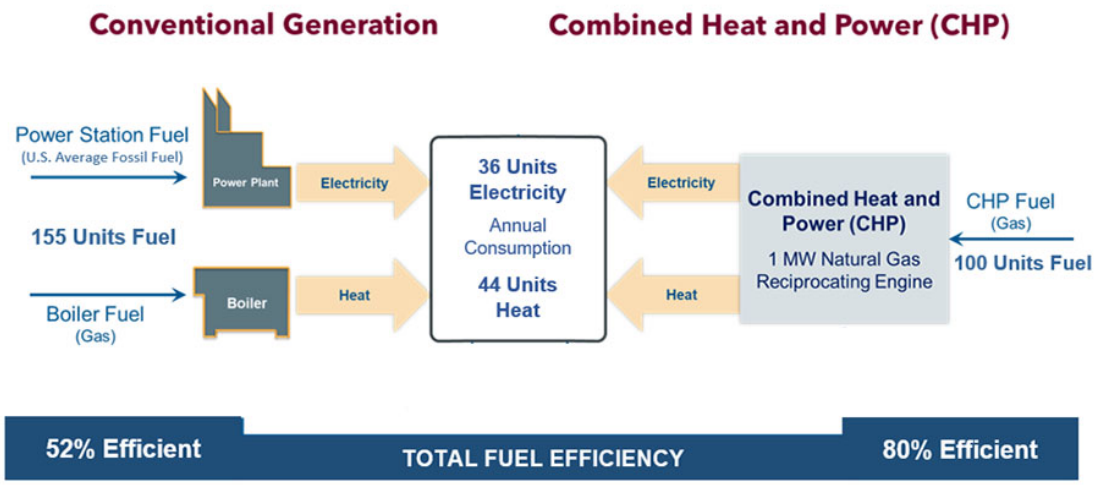
Microgrids (MG)

A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid.

CHP and Microgrids can disconnect from the traditional grid to operate autonomously



What is CHP?



- Centralized electricity generation and on-site boilers achieve a combined energy efficiency of 50% to 55%.
- Integrated CHP plants can achieve up to 80% combined efficiency while producing the electricity and thermal energy needed on site.

Image Source: https://www.epa.gov/chp/chp-benefits

CHP Prime Movers

GAS TURBINES

- High reliability
- Low emissions
- High-grade heat available
- Low GHG's
- Synchronous generation
- 500 kW to 250 MW

MICRO TURBINES

- CARB DG emissions certified
- High part-load efficiency
- Low maintenance costs
- Modular design
- Synchronous or Inverter-based
- 30 kW-10 MW

RECIPROCATING ENGINES

- High power efficiency
- Low GHG's emission
- Low cost & maintenance
- Runs on low-pressure gas
- Synchronous generation
- 60 kW to 6 MW

FUEL CELL CHP

- Low Noise
- Base load only
- Modular design
- 300 kW to 2.8 MW
- High price
- Not all FCs run in CHP mode

CHP in Microgrids

Resiliency In The Face of Reliability Failures

- Microgrids with black-start capability can respond to grid outage.
- Microgrids can relieve the grid of load at critical times to allow surround communities to stay energized.

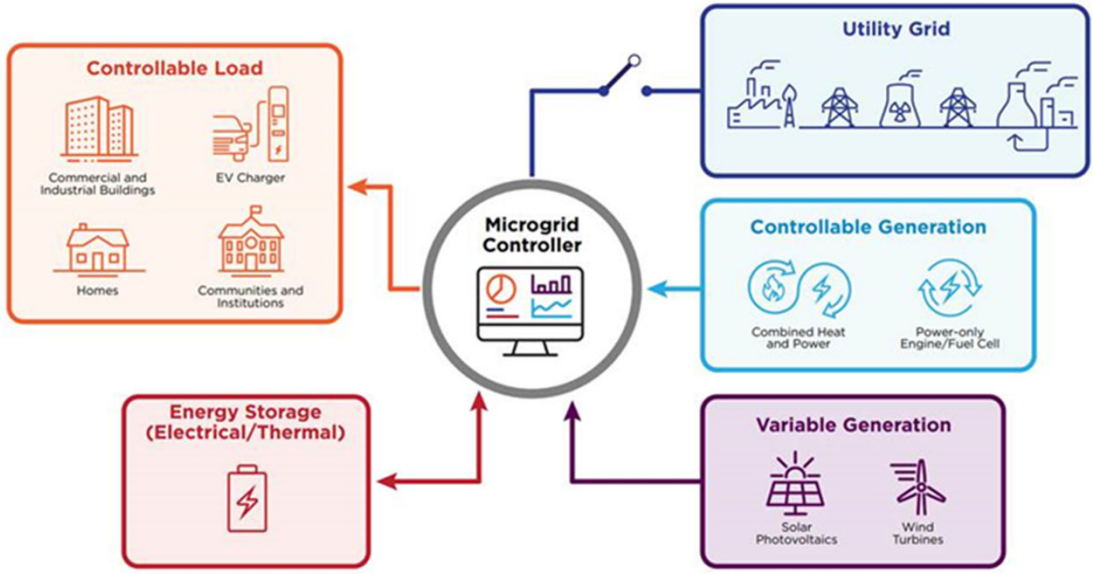


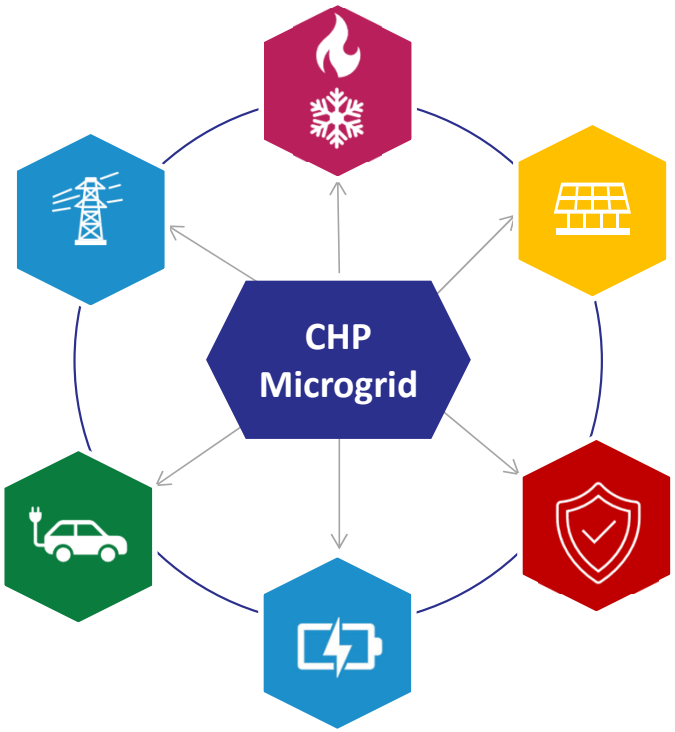
Image credit: https://www.epa.gov/chp/chps-role-providing-reliability-and-resiliency

CHP in Microgrids

DOE Grid Modernization Initiative

Microgrid metrics for Resiliency Planning

- Reliability
- Flexibility
- Sustainability
- Affordability
- Security
- Resiliency



https://www.energy.gov/sites/prod/files/2021/02/f82/GMI_Strategy_FINAL%20as%20of%201.20.21.pdf

CHP in Microgrids – Reliability & Resiliency

Decreasing Capacity: - Retirement of gas and nuclear plants - Drought Impacts – Hydro generation - Imports compromised - Firm capacity procurement challenges	Grid Readiness: - New grid - Updating will take years - **CA utilities are 5 years behind on 50 transmission projects!**

Increasing Load:
- EV Charging
  - Mid size fleet today needs approximately 50 kW
  - Mid size EV fleet needs 35MW – 50MW
- Building electrification
  - Water heating
  - Space heating
	CHP & CHP Microgrid Technology
	- Augment the local grid with Reliable energy in front of the meter (IFM) and behind the meter (BTM).
	- Dispatch to the grid and island from the grid.
	- Provide ancillary services to the grid.
	- High quality electricity and **thermal** energy.

CHP in Microgrids - Flexibility

Nimble CHP: - Flexible ramping of capacity to match load intermittency and has long duration capabilities	Storage: - Batteries play a key role but cannot run for days and weeks. CHP + Thermal Energy Storage (TES) provides robust flexibility
Diverse Fuel Supply: - CHP runs on natural gas, propane, renewable natural gas (RNG) and hydrogen (H2) blends.	Grid Flexibility: - CHP can dispatch capacity to the grid, and with a microgrid can island away from the grid relieving it of load during critical times to support the surrounding community.

CHP in Microgrids - Sustainability

Integration of Renewables & Storage: - A CHP Microgrid integrates a higher concentration of renewables and energy storage to provide needed energy with the smallest environmental impact.	Higher Efficiency: - CHP is the most efficient way to make energy with natural gas by providing a mix of electrical and thermal energy for BTM use achieving as much as 80% fuel efficiency.
Smaller Physical Footprint: - Many renewables require a lot of physical space that isn't available to all property owners, CHP can produce energy using much less space.	Renewable Fuels: - CHP systems can take advantage of a variety of fuels including RNG sourced from methane capture or even power to gas.

CHP – GHG Emission Reduction

- *Landfill gas (LFG)*
- *Animal manure*
- *Water resource recovery facilities (WRRF)*
- *Food waste*

- *Agricultural residue*
- *Forestry and forest product residue*
- *Energy crops*
- *Municipal solid waste (MSW)*

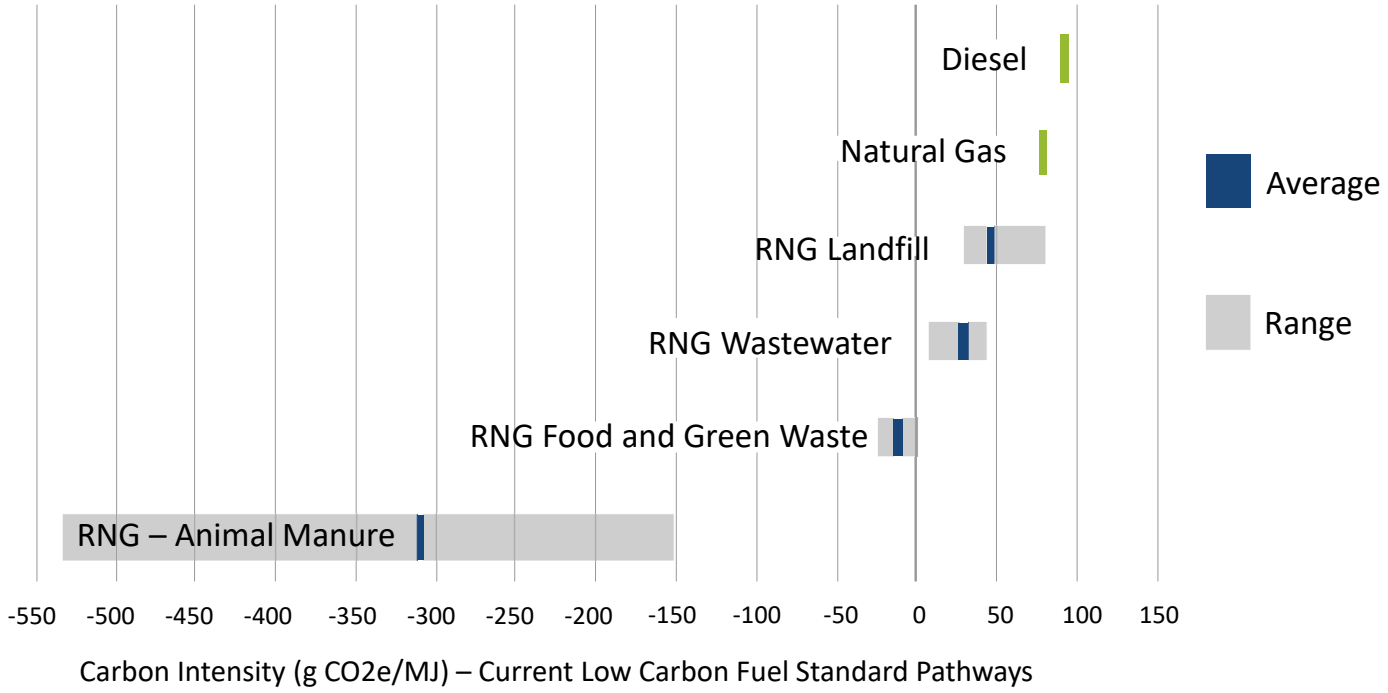
- *Renewable electricity*

Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019

CHP – GHG Emission Reduction

RNG:

- Contributes to sustainable waste management
- Reduces methane from organic wastes
- Displaces fossil fuels



Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019

CHP – GHG Emission Reduction

- CHP and renewables displace marginal grid generation - (including T&D losses)
- Marginal generation is currently a mix of coal and natural gas in most regions of the US
- Natural gas CHP's high net electric efficiency and high annual capacity factor result in energy and emissions savings on par with PV and wind
- Natural gas CHP is more efficient than state-of-the-art natural gas marginal generation (NGCC)

Category	10 MW CHP	10 MW PV	10 MW Wind	10 MW NGCC
Annual Capacity Factor	85%	26.1%	37.4%	57.6%
Annual Electricity, MWh	74,460	22,864	32,762	50,458
Annual Thermal Provided, MWh_{th}	97,505	None	None	None
Annual Energy Savings, MMBtu	**265,086**	**203,042**	**290,950**	**115,074**
Annual CO_2 Savings, Tons	**33,533**	**17,159**	**24,501**	**18,403**
Annual NOx Savings, Tons	38.5	12.5	17.9	26.0

Savings based on EPA eGRID Non-Baseload Generation as a first level estimate of displaced marginal generation

Prepared by: Entropy Research, LLC

CHP in Microgrids - Affordability

Energy Efficiency Equals Cost Savings: - Waste heat recovery is the source of CHP's high efficiency - Savings today and in the future - Stabilized energy rates	High Capacity Factor: - CHP has a very high capacity factor (CF) of over 90% compared to renewables. - If storage or backup generators are added CF can be as high as 99%.
Additional Value Streams: - Peak shaving and demand charge management - Demand response & resource adequacy - Ancillary services	No other configuration of technologies can reach this level of efficiency

Attractive CHP Markets

Industrial

- Chemicals
- Refining
- Food processing
- Petrochemicals
- Natural gas pipelines
- Pharmaceuticals
- Rubber and plastics
- Pulp and paper

Commercial

- Data centers
- Hotels and casinos
- Multi-family housing
- Laundries
- Apartments
- Office buildings
- Refrigerated warehouses
- Restaurants
- Supermarkets
- Green buildings

Institutional

- Hospitals
- Schools (K–12)
- Universities & colleges
- Wastewater treatment
- Correctional Facilities

Agricultural

- Dairies
- Wood waste (biomass)
- Concentrated animal feeding operations

University of California San Diego
San Diego, California

Project Snapshot: CHP Microgrid

Application	University
Capacity	30 MW
Prime Mover	Gas turbines, steam turbine
Fuel Type	Natural Gas
Thermal Use	Hot water and space heating
Installation Year	2001

Project Highlights: Two 13.5 MW Solar Turbines gas turbines configured with a 3 MW Dresser-Rand steam turbine, 2.8MW fuel cell, 2.4 MW solar PV, 2.5 MW battery storage system and 4-million-gallon thermal energy storage serve this campus.

University of California, San Diego (fuel cell installed in microgrid).
Photo courtesy of UCSD

Project Testimonial

"We are continually building on efforts to reduce our carbon footprint. The microgrid is a vital part of our comprehensive approach to creating a sustainable campus."

- Gary Matthews, Vice Chancellor of Resource Management and Planning

Western CHP TAP - https://chptap.ornl.gov/profile/356/UCSDMicrogrid-Project_Profile.pdf

Marine Corps Air Ground Combat Center
Twentynine Palms, California

Project Snapshot: CHP Microgrid

Application	Military
Capacity	16.4 MW
Prime Mover	Gas turbines
Fuel Type	Natural Gas
Thermal Use	Space conditioning, high-temp hot water
Installation Year	2003, addition in 2013

Project Highlights: Three gas turbines with heat recovery and seven double-effect absorption chillers totaling 3,150 tons serve the combat center. Currently 9.6 MW of solar photovoltaics is installed and 9 MW of 4-hour battery storage is planned to be installed to complete the microgrid.

Two Mercury gas turbines.
Photo courtesy of Twentynine Palms

Project Testimonial

"in 2020, 29 Palms will have complied with a Navy directive to make defense and task critical assets resilient and reliable by 2030. CHP has served as the underpinning of this endeavor."

- Gary Morrissett, Energy Manager, MCAGCC

Western CHP TAP - https://chptap.ornl.gov/profile/338/MCAGCC-Project_Profile.pdf

Taylor Farms
Gonzales, California

Project Snapshot: CHP Microgrid

Application	Food Processing
Capacity	2 MW
Prime Mover	Reciprocating engine
Fuel Type	Natural Gas
Thermal Use	Ammonia refrigeration
Installation Year	2017

Project Highlights: One 2 MW natural gas fueled reciprocating engine generator with heat recovery drives a 240-ton aqueous ammonia absorption chiller with the thermal output from the generator. The microgrid also includes 1 MW of solar photovoltaics and 1.8 MW of wind to meet their energy needs.

The CHP system currently provides 64% of the facilities power consumption.
Photo courtesy of Concentric Power.

Project Testimonial

"Plummeting prices for renewables, grid reliability concerns, and escalating retail electricity prices are accelerating the market for dispatchable CHP systems as an anchor for multi-technology intelligent Microgrids."

- Brian Curtis, CEO, Concentric Power

Western CHP TAP - https://chptap.ornl.gov/profile/440/TaylorFarms-Profile.pdf

US DOE CHP Program Resources: energy.gov/chp

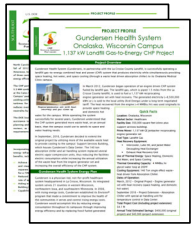
[CHP and Microgrid Installation Databases]

[Packaged CHP eCatalog]

[DOE CHP Technologies Fact Sheet Series]

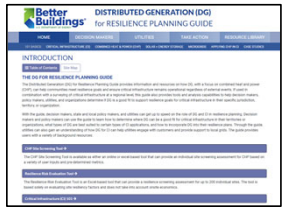
[State of CHP Pages]

[DOE Project Profile Database]



[DOE Policy/ Program Profiles]

[DG for Resilience Planning Guide]



[CHP Issue Brief Series]

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Thank You!

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