2G develops and produces combined heat and power and Gas-to-Power solutions Source : 2G Energy

Grid Congestion: a Global Energy Challenge

Think of the electricity grid like a sprawling highway system, engineered to handle a steady flow of traffic. During off-peak hours, vehicles glide smoothly. But come rush hour, too many cars flood the lanes. Traffic slows. Bottlenecks form. And suddenly, the entire network feels the strain.

This is precisely what happens during grid congestion. Only instead of cars, it's electricity. Instead of delays, it's energy inefficiency, curtailed renewables, and even blackouts. Technically speaking, congestion occurs when components of the grid — such as transmission lines or transformers — are pushed beyond their designed limits, unable to handle the surging demand or redirected flows from renewable energy sources. Even the European Commission's Joint Research Centre projects that without faster grid expansion, renewables redispatch could increase sixfold by 2040, resulting in up to 310 TWh of wasted energy annually – equivalent to half of 2022 EU wind and solar output.[1)]

A system under pressure: electrification and the rising load

As grid congestion continues to grow in complexity and severity, it's becoming increasingly clear that centralised power systems alone can no longer meet the dynamic needs of today's energy landscape. Rapid electrification of transport and heating, surging renewable integration, and rising digital energy demand – from industries like data centres – are all placing intense pressure on national grids.

A key driver behind this growing challenge is the electrification of sectors traditionally powered by fossil fuels, namely heat and transport. Electric vehicles, heat pumps, and electrified industrial processes are all placing new and substantial demand on the grid – often in places and at times where the grid is least prepared.

1) https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/more-coordination-needed-renewable-deployment-prevent-grid-congestion-2024-05-27_en?utm_source=chatgpt.com

Additionally, the increased adoption of intermittent renewable energy sources like wind and solar adds another layer of complexity. When these sources generate power, they do so based on weather, not demand. This means surplus energy can flood the grid, especially when generation is high but consumption is low – another cause of congestion.

Further complicating the picture is the explosive growth of data centres, which now account for approximately 1.5% of global electricity consumption – a share projected to more than double by 2030, reaching nearly 945 TWh – yet many are located in regions without robust grid infrastructure, posing a risk of local congestion.[2)]

Lastly, structural causes cannot be ignored: ageing infrastructure, increasing demand for energy supply, lack of long-term investment in transmission upgrades, and regulatory bottlenecks are all exacerbating the problem.

[2)] https://www.scientificamerican.com/article/ai-will-drive-doubling-of-data-center-energy-demand-by-2030/?utm_source=chatgpt.com

A decentralised way forward: local energy generation as a strategic solution

To navigate these challenges, a shift toward decentralisation and local energy generation is essential (Figure 1). The future of energy must be more flexible, resilient, and localised. A key player in this decentralised approach is combined heat and power (CHP) technology.

CHP plants – also known as cogeneration systems – produce both electricity and usable heat from a single fuel source. This simultaneous generation significantly increases overall energy efficiency, often achieving efficiency rates of 80% or more, compared to the much lower combined efficiency of conventional separate heat and power systems. By utilising the waste heat that would otherwise be lost in traditional power generation, CHP maximise fuel use and reduce overall energy costs.

In addition to CHP, decentralised Gas-to-Power (GtP) solutions based on engine power plants are also gaining importance. These systems convert natural gas or renewable gases directly into electricity using high-efficiency gas engines (Figure 2). Like CHP, GtP units can be deployed close to the point of demand, offering flexibility, rapid response capability, and reliable power generation – even in regions with unstable grids or limited infrastructure.

By placing power generation closer to the point of consumption, CHP and GtP systems reduce strain on long-distance transmission lines and offer an effective buffer against network congestion. Their decentralised nature supports energy autonomy at the local level, providing communities and facilities with greater control over their energy supply.

Both CHP and GtP systems are also capable of operating in island mode, continuing to supply power even when disconnected from the main grid. This functionality enables localised backup power during outages or emergencies, further enhancing energy security and resilience. This is particularly crucial for sectors such as healthcare, waste management, and wastewater treatment.

Unlike intermittent renewables, CHP and GtP solutions offer on-demand generation and are not weather-dependent. They are fast,

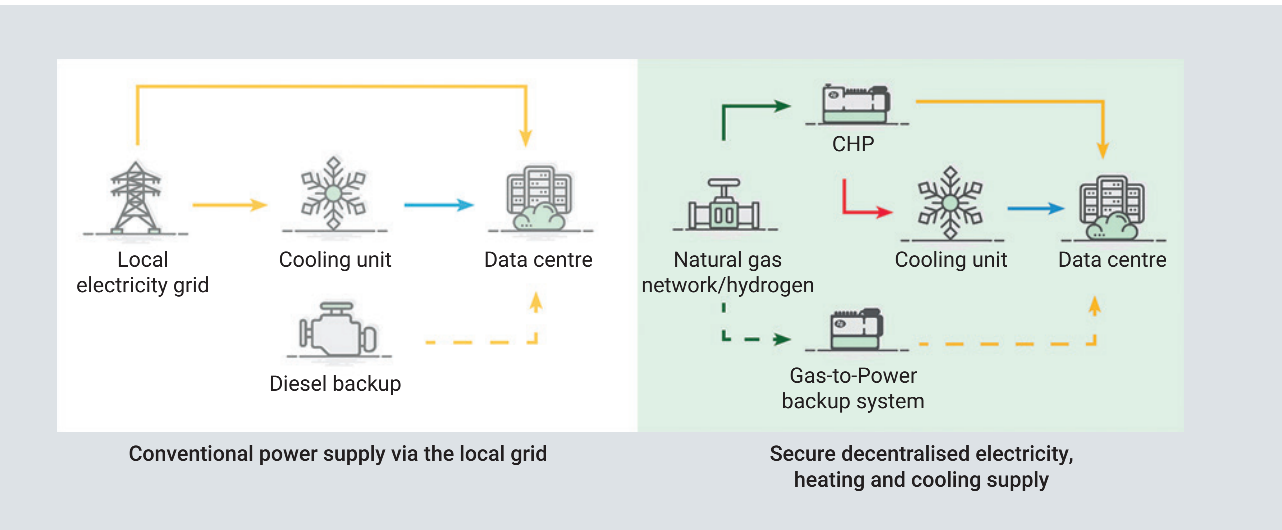

Figure 1. As centralised power systems alone can no longer meet the dynamic needs of today's energy landscape, a shift towards decentralisation and local energy generation is essential Source : 2G Energy

efficient, and highly reliable – qualities that make them exceptionally well-suited to address the challenges of grid congestion while strengthening local energy independence.

CHP systems at work in demanding environments

CHP systems offer technical and operational benefits in countries exposed to challenging weather conditions such as hurricanes, strong winds, coastal corrosion, and extreme temperatures. These environmental factors often place considerable strain on conventional energy infrastructure, increasing the relevance of decentralised and resilient energy solutions.

A key functional feature of many CHP systems is their ability to operate in island mode. This allows them to continue supplying electricity and heat independently from the central grid in the event of outages caused by storms or other disruptions. In regions affected by frequent grid instabilities, this capability plays a critical role in maintaining essential services such as hospitals, emergency response units, water treatment plants, and communication infrastructure.

CHP units are commonly installed on-site or near the point of consumption, reducing dependence on long-distance transmission lines. This is particularly advantageous in coastal areas, where salt-laden air and high wind exposure can accelerate wear and cause failures in grid infrastructure. By decentralising energy generation, CHP systems help improve system reliability and energy security.

These systems are also designed to function reliably under extreme temperatures. Their compact and enclosed construction, combined with flexible fuel capabilities, enables stable performance even in hot and humid conditions. In addition to generating electricity, the systems recover and utilise waste heat for thermal applications, which contributes to improved overall efficiency and can help reduce energy costs – especially in climates with high seasonal demand.

Manufacturers such as 2G Energy develop CHP units with a high degree of fuel flexibility (Figure 3). These systems can operate using a variety of gaseous fuels, including natural gas, biogas, liquefied gas, propane, and hydrogen blends. This adaptability enables the use of locally available or renewable resources, reduces reliance on conventional energy sources, and supports the broader transition towards lower-emission energy systems.

Figure 2. Gas-to-Power solutions convert natural gas or renewable gases directly into electricity using high-efficiency gas engines Source: 2G Energy

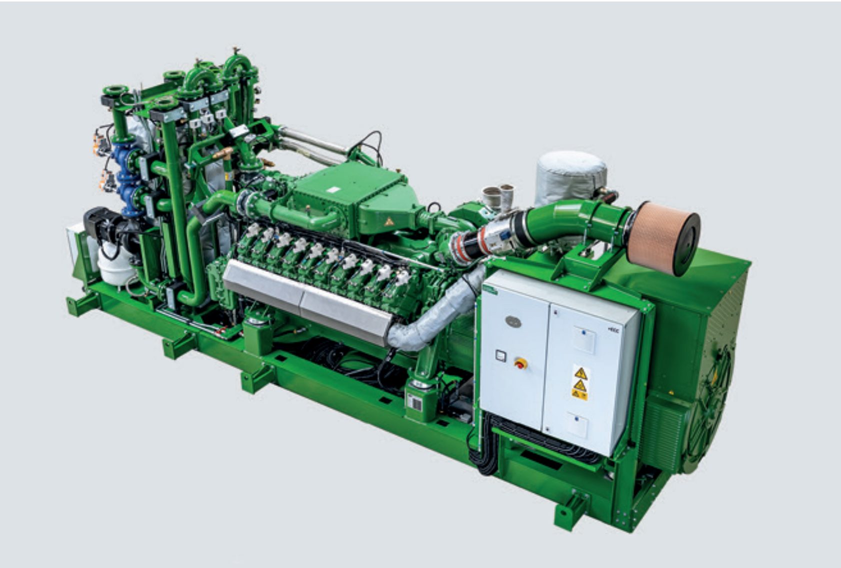

Figure 3. CHP units like the Avus from 2G Energy can operate using a variety of gaseous fuels Source: 2G Energy

In summary, CHP technology offers a resilient and efficient option for strengthening energy systems in regions with harsh environmental conditions. Its decentralised design, operational stability, and adaptability to different fuel types make it a relevant component of long-term strategies aimed at improving energy security and infrastructure resilience.

Leading the way

2G, a leading producer of its own advanced energy systems in the field of CHP and GtP, possesses extensive international expertise in the development and implementation of microgrids and island mode operations, successfully delivering these technologies across a wide array of projects worldwide. These include applications in regions with unstable grid conditions, remote locations, and critical infrastructure requiring uninterrupted power supply. Through this global engagement, 2G has gained practical insight into the technical and operational challenges associated with decentralised energy systems, enabling it to refine and adapt its solutions to a wide variety of local contexts.

Frank Grewe, CTO at 2G, highlights the company's long-standing commitment to technical excellence and economic efficiency: "From the beginning, we've built 2G on a foundation of high technological and quality standards. Our products' strong cost-effectiveness is largely driven by consistently low Opex." He further emphasises the critical importance of reliability in modern energy systems: "With demand response, we are talking about a short runtime, but it must then be delivered with absolute reliability as soon as a network bottleneck threatens." This focus on responsiveness and dependability underpins 2G's approach to supporting grid stability and flexibility.

2G's systems have been deployed in environments where maintaining power autonomy is essential, such as hospitals, industrial facilities, and wastewater treatment plants. These experiences have allowed the company to develop robust control systems and operational protocols that ensure seamless transitions between grid-connected and islanded operation.

In addition to its practical project experience, 2G places strong emphasis on research and development as a foundation for improving system performance and long-term reliability. This includes work on optimising control algorithms, improving fuel flexibility, and integrating CHP systems with other distributed energy resources such as photovoltaics, heat pumps, and hydrogen technologies. By focusing on both applied and forward-looking innovation, 2G contributes to advancing the role of CHP in modern, decentralised energy systems.

Policy pathways to expand CHP impact

To fully unlock the potential of CHP technology for decentralised and backup energy applications, a supportive regulatory and policy environment is crucial. Policymakers have a key role to play in enabling broader adoption by creating favourable conditions and reducing barriers.

This begins with formally recognising CHP as a key resilience measure within national energy strategies. Streamlining approval processes and simplifying permitting procedures for decentralised energy systems would also help accelerate deployment. In addition, targeted incentives can encourage investment in projects that pair high-efficiency CHP with grid relief, renewable energy integration, or support for critical infrastructure.

Another important step is facilitating market access for the surplus electricity and heat generated by CHP systems – particularly in connection with district heating networks. By enabling these systems to operate flexibly and economically, policymakers can help ensure they become a central pillar of a more resilient, efficient, and sustainable energy future.

A smarter, more resilient energy future

Grid congestion is not a passing nuisance – it's a structural weakness in today's energy transition. If left unaddressed, it risks turning the clean energy dreams into an unreliable and expensive reality. But with decentralised solutions like CHP and GtP solutions, backed by experienced players like 2G, the tools to meet this challenge head-on are available. The future grid must be smarter, more localised, and more resilient and that future begins with forward-thinking policy, investment, and technology.

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