VERTIV WHITE PAPER

Achieving Carbon Neutrality with Hybrid Eco-Systems: Strategies for Combining Sustainability with Reliability

Executive Summary

Hybrid eco-systems offer several ways of reducing climate impact for businesses and organizations working to improve their carbon footprint. While hybrid power is not in itself a green technology, it can be used to reduce carbon emissions and achieve green operations in an eco-system and simultaneously reach different operational targets. Battery energy storage systems and intelligent power management are two key factors in designing and operating a future-proof, reliable hybrid eco-system.

Is Green Uptime possible?

More and more businesses and organizations are taking steps to reduce their climate impact by reducing carbon emissions from their operations. There are several good reasons for doing so; in addition to complying with regulatory requirements, businesses and organizations may need to satisfy customer demands for green operations and often have ambitious climate targets of their own. The data center industry, for example, has committed to achieving carbon neutrality by 2030, reaching 75% of this goal already in 2025.

The Data Center Industry has committed to achieving carbon neutrality by 2030

Increasing the use of renewables such as wind turbines, PV panels, and fuel cells, and reducing dependence on fossil powered energy sources such as diesel gensets, is one way of reducing climate impact. Renewables have come a long way in recent years, and technologies such as wind turbines and PV panels are now mature, efficient, and competitive.

Renewables on the Rise

Preliminary calculations showed that approx. 46% of Germany's power consumption in 2020 was covered by renewables, according to the German energy industry association BDEW and the center for Solar Energy and Hydrogen Research in Baden-Wuerttemberg (ZSW) .

There is, however, still a drawback to increased reliance on renewables: Their inherently unstable nature runs counter to the need for uninterrupted power; to put it very simply, you can't power a server rack from a PV panel on overcast days.

So, do power professionals have to choose between sustainability and reliability, or is it possible to combine renewables with uninterrupted uptime? The answers to these questions are no and yes: With hybrid eco-systems, operators can employ various strategies for reducing climate impact while ensuring constant power through a combination of power sources. In addition, hybrid eco-systems can be used to run fossil-fueled power sources more efficiently, thereby lowering fuel consumption and climate impact.

In short: green uptime is possible; sustainability can be combined with reliability. In this whitepaper, we will explain what a hybrid eco-system is, provide recommendations for designing hybrid eco-systems, and explore some of the strategies for climate impact reduction that they provide.

No One Power Source is ever 100% available

While gensets and grid power are usually considered more reliable than renewables, not even these power sources are a guarantee of 100% availability:

- If a genset is not maintained and tested properly, it may not start when needed. Common causes of genset failure include battery or starter failure, insufficient coolant, and control setting errors.
- Power grids can also be brought down by malfunctioning equipment, with widespread negative consequences. In February 2021, for example, the US state of Texas suffered a power crisis because much of the state's power generation equipment was unprepared for a series of severe winter storms. In addition to an estimated USD 10 to 20 billion of estimated insured losses, the event resulted in the loss of more than 100 lives.

Main features and benefits of integration and segregation

What is a Hybrid Eco-System?

- A solution using a combination of two or more different power sources, one or more of which are renewables
- Enables the operator to reach different operational targets such as reducing fuel consumption and emissions

Even though hybrid eco-systems are often used to reduce climate impact (for example in cars), hybrid power, by definition, is not necessarily green. It is a solution covering a given load demand using a combination of two or more different power sources. With a hybrid power solution, the operator can combine the connected sources as needed to exploit their benefits and reach different operational targets. When renewables are included in a hybrid solution, it is often called an ecosystem.

Examples of hybrid eco-systems include mains power with genset backup, a wind or PV plant with battery storage, or a setup that combines many power sources: mains power, gensets, several renewables, and battery storage.

Definition of Hybrid Eco-System

Hybrid power is a solution covering a given load demand using a combination of two or more different power sources. The operator can combine the connected sources as needed to exploit their benefits and reach different operational targets. When renewables are included in a hybrid solution, it is often called an eco-system.

The flexibility of a hybrid eco-system makes it ideally suited for reducing climate impact because the operator can configure the system to run in a climate-friendly way. There are many ways of doing this, and not all of them involve solutions traditionally considered green, such as using wind turbines or PV panels.

A hybrid eco-system, for example, can be used to run diesel-powered gensets at optimum efficiency. By doing so, the fuel consumption and carbon emissions of these gensets are reduced, lowering their climate impact. This is a climate-friendly approach compared to gensets that produce the same power but consume more fuel and produce more emissions.

Let us take a look at how a hybrid eco-system can be set up and controlled.

Example of Hybrid Eco-System Design

In this example of a hybrid eco-system, the load demand can be covered using power from the mains, gensets, PV panels, a wind turbine, or a battery energy storage system (BESS). Each power source is managed by a dedicated controller, and all controllers are interlinked (using two communication lines to ensure redundancy). The entire system is linked to the SCADA system through a PLC-based gateway. If the system had to handle big loads, the load could also be monitored using dedicated load controllers.

A hybrid eco-system could easily include more power sources, for example hydro power or gas turbines, or it could have fewer sources (as long as there were at least two). It could also be controlled in other ways; we will discuss efficient control strategies below. For now, the most important point is that the system, through its combination of power sources, is capable of reaching many different operational targets – often even at the same time:

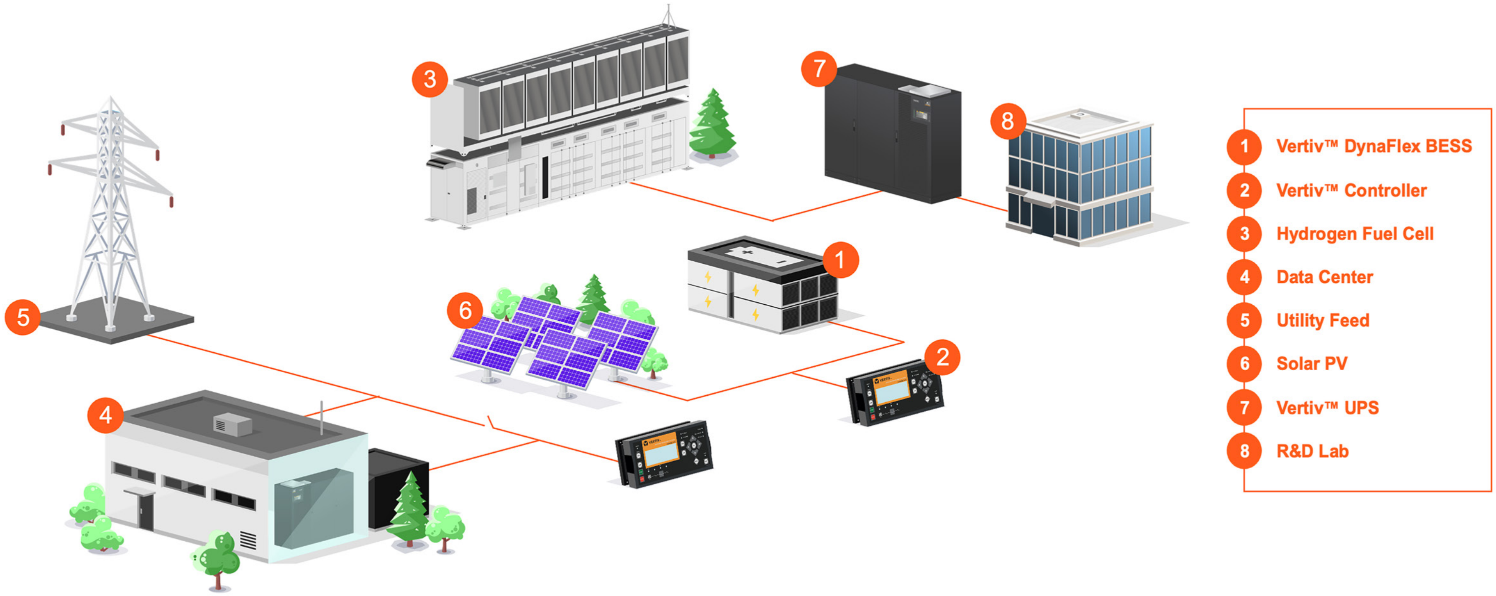
- Maximizing the use of renewables
- Improving power system resilience
- Optimizing equipment operation
- Lowering fuel costs

In the following, we will look at some key features of the hybrid eco-system and discuss the strategies that they enable for reducing climate impact while ensuring uptime and reaching other targets.

BESS: A Good Place to Start

- Counteracts power source instability
- Allows the operator to optimize power system operation in several ways

One important key to achieving an efficient hybrid ecosystem is to add a battery energy storage system (BESS). Recent advances in battery technology (including vanadium redox flow batteries) mean that a BESS can now offer sufficient storage capacity to make them a viable proposition in many power applications, and they can be used in many ways depending on your objectives.



Storage of Power from any Source

The key benefit, of course, is that a BESS stores power from other sources and lets you decide when and how to use it. This lets you counteract the instability of your power sources, particularly (but not only) renewables: In case one or more power sources are temporarily offline, you can use the BESS to compensate until other sources become available again (or until the BESS is depleted). Until technologies such as power to X and thermal storage are mature and ready for the market, a BESS is the only feasible solution for storing energy produced from other sources.

Fast-Reacting Power Source

While gensets can also be used to provide backup power, a BESS is a fast-reacting power source that lets you handle load changes instantly whereas gensets, even at the best of times, require a few seconds to start up and synchronize. This combination of flexible storage and instant power when required provides the basic resilience that is needed in any critical power system.

Strategies with a BESS

Using renewable power even when renewables are offline

- If you have renewables in your setup, you can store unused renewable power in the BESS and use it later when the renewables do not produce sufficient power, for example because of adverse weather conditions. By doing so, you can ensure maximum renewable power penetration.

Limiting genset use

- If neither the grid nor your renewables produce enough power to cover the current load demand, the BESS allows you to run reliably on cheap and/or green stored power (until the BESS is depleted) instead of starting up one or more gensets. By doing so, you save fuel and emissions and reduce the number of genset starts/stops.

Optimizing genset use

When you do start your gensets, you can run them at their optimal duty point (for example 70% load) because the BESS can provide or demand power if needed. By doing so, you improve fuel efficiency, reduce emissions, reduce the need for maintenance, and prolong genset service life.

Example: If a genset is running at 40% load, the BESS can demand charging power, raising the genset load to 70%. Conversely, if the genset is running at a high 95% load, the BESS can discharge power, supporting the genset so its load drops to the optimal 70%.

Avoiding High Grid Power Tariffs

- If grid power tariffs vary over the course of the day, you can charge the BESS from low-tariff grid power (for example at night) for use later when tariffs are higher.
- If your agreement with the utility means that you pay higher tariffs for power consumed beyond the scope of the agreement, the BESS can supply the extra power needed during peak power demand periods, so you avoid higher tariffs.

The Necessity of Intelligent Power Management

- Ensures flexible, scalability, resilience, and compliance with operator requirements
- Easy to set up, maintain, run, and reconfigure

Managing the power sources in a hybrid eco-system requires a control solution capable of coordinating all power sources to ensure uninterrupted power and reach the operator's performance targets.

There are several ways of setting up a hybrid eco-system control solution. One traditional way of handling power system control is to set up a peer-to-peer system in which a peer controller controls and coordinates a number of peer controllers managing each power source and other key components such as loads and bus tie breakers. This is a tried and tested approach, but in a hybrid power context, there are two main drawbacks:

- Programming each controller for use in a hybrid power setup is a huge task. There are many power sources that need to be coordinated, and the logic must therefore take many different operating scenarios into account to provide operational flexibility and stability.
- As with other power systems, if the controller fails, there is no control or coordination of the power sources. This can be solved by purchasing backup controllers for each controller on the network, but this is usually prohibitively expensive, and it requires even more customized programming.

PMS: A Better Alternative

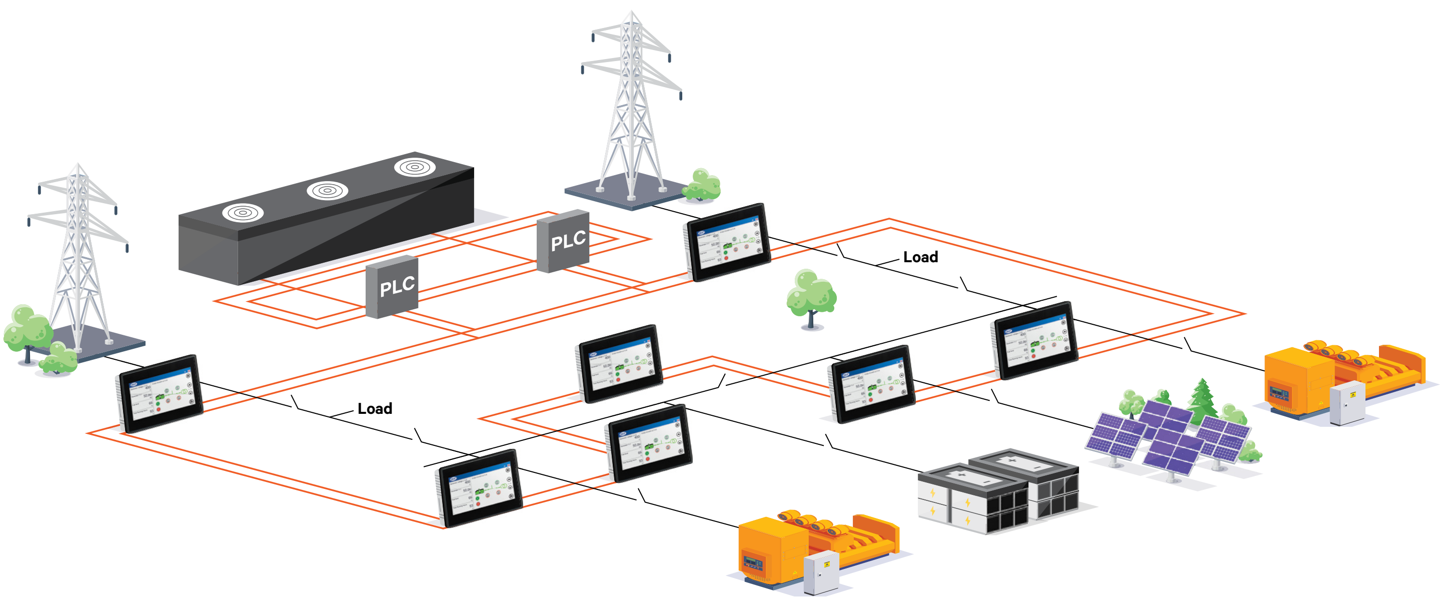
Using an intelligent power management system (PMS) based on a network of decentralized controllers (as shown in the illustration on page 5) is a better alternative. A PMS automatically manages and optimizes the operation of the hybrid eco-system based on operator requirements.

Each controller handles one power source, for example a grid connection, genset, wind turbine, or BESS. Status information about the current load demand and the current power production of each connected source is continuously exchanged between the controllers, and they use this information to coordinate which power source to prioritize based on the user's requirements.

Controller Redundancy

The decentralized controls provide a management solution in which any controller can assume the control duties of another controller. If one of the peer controllers fails, another controller can assume control of the system, ensuring that system control is not compromised. Such an intelligent system is called a peer-to-peer solution. To ensure full redundancy throughout the control architecture, it is very important to use two separate cables with separate communication ports on the backbone of the PMS.

> *A PMS automatically manages and optimizes the operation of the hybrid eco-system based on operator requirements.*



PMS or EMS?

A power management system (PMS) is sometimes referred to as an energy management system (EMS). In this whitepaper, we consistently use the term power management system, or PMS.

Strategies with an Intelligent PMS

Maximising green power penetration

- The PMS can be set up to prioritize renewables whenever possible. On a bright, windy day, for example, it could cover the load demand using wind turbines while charging a BESS from the PV panels. If the wind dropped but the sun was still out, the system could automatically switch to cover the load demand using the PV panels (and stop charging the BESS). Some PMS controllers for renewables are factory configured to maximize sustainable power penetration in any application.

Optimizing genset operation

- As explained above, gensets running at their optimum duty point consume less fuel and produce fewer emissions. The task of controlling and coordinating the power sources in the hybrid ecosystem can be handled by the PMS so that each genset is operated optimally. If several gensets with different power ratings are available, the PMS can combine them to achieve the most efficient operation possible, and additional load requirements can be covered by using other sources if necessary.

Ensuring resilience

- The PMS constantly monitors the load and all connected power sources and ensures that the required power for the load point is always available by switching power sources on or off as required. If the system was running on PV panel power, for example, and clouds then rolled in, the system could switch to a different power source in time, for example by starting up gensets, drawing on a BESS, or switching to grid power. A PMS will often have advanced features such as minimum genset load or spinning reserve (see key terms explained) that help you attain the greatest possible security of supply and maximum green power penetration – simultaneously.

Accommodating all power source types

- Some intelligent PMS solutions are capable of handling and coordinating all types of power source: grid connections, gensets, PV panels, wind, hydro, and gas turbines, and BESSes. The two critical parameters are to get controllers that are compatible with one another, and which are designed and configured to handle each individual power source type.

Enabling easy system reconfigurations

- With an intelligent PMS, the hybrid eco-system can be scaled up or down as required. When you use compatible and intelligent controllers, adding an additional genset or PV panel, for example, with a controller that is compatible with the rest becomes very easy. Intelligent PMS solutions will often automatically onboard the new controller as soon as it has been connected, including the new controller and its power source in the power management logic, and ensuring that your objectives are met.

Importantly, several of these benefits can be achieved simultaneously. A hybrid power system with an intelligent PMS, for example, could be set up to maximize sustainable power penetration but still keep an eye on the load demand, immediately switching between power sources as needed, thereby also ensuring uninterrupted uptime. If the PMS needed to start up one or more gensets, it could combine them with other power sources (if available) to optimize genset operation and lower fuel consumption and emissions, again combining sustainability with reliability.

Doing It At Your Own Pace

- Hybrid eco-systems are not all or nothing at all
- Advice and recommendations

Going from 0 to 100% renewable power in one go is rarely feasible, and the same applies for other changes to existing power solutions: Changes very often need to be phased in gradually. Investments may need to be divided over several budget periods, and uptime concerns prompt a cautious approach when carrying out system upgrades or redesigns.

Fortunately, hybrid eco-systems are not all or nothing at all. With flexible, scalable, and re-configurable controllers interlinked in an intelligent PMS capable of handling both fossil and renewable power sources and power storage, system components can be updated as required and at the operator’s own pace.

> *With an intelligent PMS, system components can be updated as required and at the operator’s own pace.*

There are several ways of going hybrid or extending existing hybrid eco-systems. Operators can purchase a new PMS designed to handle hybrid eco-systems or integrate a BESS or renewable in an existing power system if the new controller can be configured for compatibility with the existing control architecture. It is a matter of deciding what your objectives are, and how quickly you need change to happen. The first step, as always, is to be clear about your requirements and your reasons for going hybrid. As explained above, hybrid and green are not the same thing, and there can be many reasons for wanting to phase in a hybrid power solution.

We recommend that you opt for flexible, future-proof, configurable controllers that can accommodate any reconfiguration or change to your hybrid eco-system. We also advise you to work with vendors who can provide the engineering, customization, and long-term support that lets you have a sustainable and reliable solution, and lets you decide the degree of sustainability and the pace of transformation to a more sustainable solution.

Conclusion

The green transformation is just that – a transformation, not a revolution. Sustainability and reliability are not mutually exclusive, and you do not need to go for 100% sustainability from the outset. There is no doubt that power professionals need to increase the share of renewables in the energy mix, but that need must be balanced against operational considerations, and the hybrid eco-system must deliver the performance that is still important to businesses and organizations, and their clients and society as a whole.

Key terms explained

- **Close before excitation** (also known as run-up sync or dead bus sync): A feature found in some genset controllers that allows any number of gensets to be started within 10 seconds or less, ensuring fast backup power. The feature closes the breakers on the busbar before ramping up and synchronizing the gensets, saving valuable time.
- **Droop compensation:** Ensuring that the voltage and frequency from a genset are within nominal values. Gensets are often set up to allow voltage and frequency fluctuations, allowing them to handle load changes better. This is known as droop. However, such fluctuations can adversely affect some loads which is why some intelligent power management controllers can compensate for droop and keep nominal values.
- **Grid-forming power source:** A power source that is able to form a V/f sine wave or support such a since wave in parallel with other sources. Grid-forming power sources are capable of operating on their own.
- **Non-grid forming power source:** A power source unable to form a V/f sine wave and therefore unable to operate on its own. Examples include PV inverters. Non-grid forming power sources can support the load by P/Q set points.
- **Spinning reserve:** Keeping one or more gensets running and connected to the busbar to ensure that they can provide fast power backup if needed. Some intelligent PMS controllers can automatically adjust the amount of spinning reserve available to match current operating conditions and load demand. In a hybrid system with a BESS, the BESS can provide backup power instead.

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