

MOBILE UPS SYSTEMS COMPARISON OF TECHNOLOGIES AND APPLICATIONS



Written by

Tom Loix
Dieter Backx

luminussolutions.be

Summary

Today, several types of loads and applications require a high-quality, uninterrupted electrical power supply (eg. datacenters, production facilities, airports...). One important element connecting these types of loads is the high cost related to an interruption of the power supply, ranging between tens of thousands up to millions of euros. For such critical loads, UPS systems have become a key element in the power supply.

This white paper focuses on mobile UPS systems, installed in a container or enclosure that is easily movable, allowing deployment on a site in need of (temporary) UPS protection. This demand has some repercussions on the system design and feasibility. A comparison of the most important UPS technologies and configurations learns that not every UPS technology is equally suitable for mobile design and application. In general, the more robust and compact technologies, such as DRUPS systems and diesel generators, are more suitable for mobile configuration, while hybrid or static UPS systems tend to be more sensitive to environmental conditions.

The integration of a mobile UPS system can be useful for protecting the power supply of critical loads on all temporary occasions, for customers who are already in possession of a fixed UPS system or not.

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Introduction

Today, several types of loads and applications require a high-quality, uninterrupted electrical power supply – examples are datacenters, production facilities in which accurate and continuous control of environmental conditions and/or process parameters is paramount, airports,... One important element connecting these types of loads is the high cost related to an interruption of the power supply: in that case, the unavailability could result in a loss of customer data and transactions, loss of products, important safety hazards,... which often imply a cost ranging between tens of thousands up to millions of euros. In order to prevent such damage (technical, economical and/or commercial), UPS systems have become a key element in the power supply of such critical loads.

This white paper focuses on mobile UPS systems. As opposed to their fixed counterparts, these systems are installed in a container or enclosure that is easily movable, allowing deployment on a site in need of (temporary) UPS protection. This demand has some repercussions on the system design and feasibility. First, the most important UPS technologies and configurations are presented and compared, focusing on the specifications required by the mobile design and application. Next, the applications and cases in which a mobile UPS provides the best answer to the customer's demands and specifications are outlined.



UPS technologies and configurations



(Photo 1 - MUPS on the road Luminus Solutions)

As stated in the introduction, the main goals of a UPS system are:

- Providing an uninterrupted electrical power supply to the critical loads connected to the UPS – independent of the utility grid conditions (long or short interruptions, voltage sags and swells...)
- Providing a high-quality voltage to the critical loads – this involves filtering and compensation of disturbances on the utility grid, e.g. voltage harmonics, dips and swells, frequency variations...
- Minimizing the impact of load-side disturbances on the utility grid – the reactive power and current harmonics drawn by the loads is delivered by the UPS system and not by the utility grid, in order to limit propagation of power quality problems and disturbances towards the utility grid (where they might impact other loads and customers).

This paper focuses on UPS systems for a rated power of 100 kVA or more. This means some UPS configurations are not mentioned, more specifically some of the static (battery) UPS configurations often used for low-power applications (e.g. offline or line-interactive static UPS systems). This section describes the most important UPS configurations for the given power range, with their principal advantages and drawbacks and opportunities for mobile application.

Static UPS systems

An online (or double conversion) static UPS system (see Figure 1) consists of the following components:

- DC-bus – this bus is used for connecting the inverter on one side and the rectifier and storage systems (batteries, capacitors, flywheel...) on the other side.
- Storage systems – the most frequently used technology is an electrochemical battery, but (ultra)capacitors and flywheels can be used as well. The systems provide the necessary energy for bridging a relatively short grid failure (typical autonomy: 5-10 seconds to 30 minutes) or the time required to start a diesel generator.
- Inverter – used for converting the DC-voltage at the DC-bus into AC-voltage at the output.
- Rectifier – used for converting the grid's AC-voltage into DC-voltage, used to supply the output inverter as well as the charging converters for the energy storage units.
- Bypass – in case of an overload condition, maintenance or a failure to the power electronic converters and/or the storage units, the UPS system transfers to the static bypass. Apart from the automatic bypass (which is activated automatically in case of an overload at the output of the UPS), most systems have a manual bypass (e.g. for planned maintenance). In bypass mode, the loads are directly supplied by the utility grid, without additional protection against disturbances and interruptions.

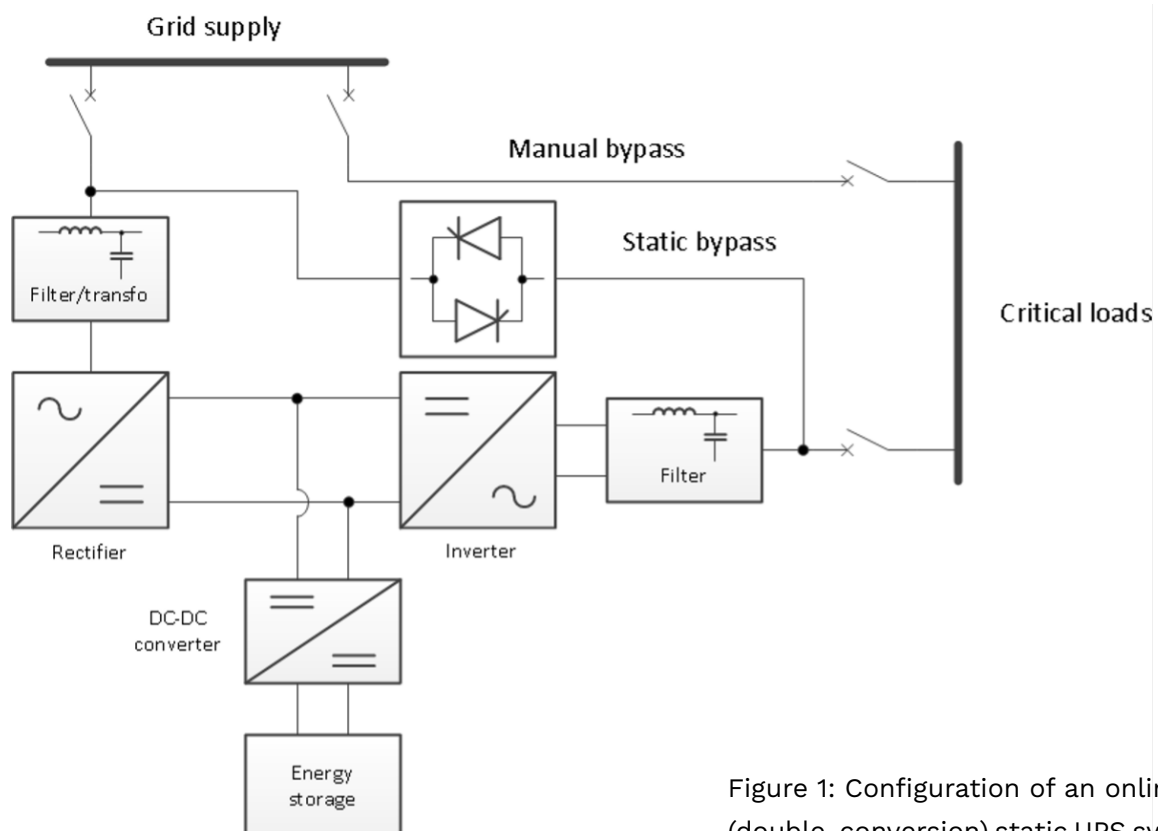


Figure 1: Configuration of an online (double-conversion) static UPS system

The main advantages of a static UPS system are:

- Modular approach: these systems are available in modules of different power ratings, most of which are fit for parallel operation. This allows an increased redundancy, optimizing the efficiency by shutting down one or several modules in case of a low power demand or starting with a small total UPS power and adding modules as the critical load power rises.
- Energy storage flexibility: a static UPS system can be equipped with various storage technologies, most often batteries, but flywheels and (ultra)capacitors are also commonly used.

The most important disadvantages of this UPS technology are:

- Need for an additional diesel generator for power supply during a long grid failure: the energy storage units usually have a limited autonomy, typically between 5 and 30 minutes at rated output power. In case of a grid outage lasting longer than the storage units' autonomy, a diesel generator (or another power supply) is required in order to provide a continuous power supply to the critical loads.
- Low short-circuit capacity: a static UPS system can only deliver 2-3 times the rated output current in case of a short-circuit at the output during emergency operation (during normal operation, the utility grid delivers the required short-circuit current through the automatic bypass circuit). This is likely to result in an insufficiently low fault current, impeding a selective disconnection in due time in case of a short-circuit downstream of the UPS system. This solution might require adapting the protection settings or installing additional protective devices.

Specifically, for mobile UPS systems, the following aspects must be taken into account:

- The UPS systems must be installed in a ventilated and air-conditioned container or enclosure – the heat generated by the converters (efficiency losses) must be evacuated in order to avoid overheating the power electronics.
- Batteries must also be installed in a ventilated and air-conditioned environment. Correct and accurate control of the temperature inside the enclosure is very important for the performance and lifetime of the batteries. Depending on the battery technology used, the optimal temperature is 20-25°C. In case temperatures are too low, the battery performance will reduce, while high temperatures compromise the battery lifetime.

- In case the UPS system needs to be able to supply the load during long interruptions (exceeding the battery autonomy, which is typically 5-15 minutes), one must add a diesel generator (or another energy source with a sufficiently large autonomy) to the configuration. The generator should be connected upstream of the UPS system, with an automatic source changeover switch. This switch has two inputs (the utility grid and the generator) and automatically transfers the power supply to the UPS system to the generator in case of a grid failure (after startup and stabilization of the generator output voltage). Upon return of the utility grid voltage within the tolerances for supplying the UPS system, the switch retransfers power supply of the UPS system to the utility grid and shuts down the generator. The diesel generator should be installed in a separate container or enclosure – see section Diesel generator for more details on this.
- In case one uses kinetic energy storage units (flywheels) as an energy source for the UPS system, one should be careful not to expose these units to shocks (most likely during transport or installation of the mobile system). The flywheels are equipped with magnetic bearings – any misalignment due to shocks can cause malfunction or damage to the flywheel.



(Photo 2 - battery storage)

DRUPS systems

A DRUPS system (short for diesel rotary UPS system, see Figure 2) consists of the following components:

- Synchronous machine – operating as a motor during normal operation (driving the kinetic energy storage unit), operating as a generator during emergency operation, supplying the critical loads.
- Energy storage – a rotary UPS system comprises a kinetic energy storage unit, the details of which differ depending on the manufacturer. This storage unit drives the generator directly after disconnection from the grid, until the time at which the diesel engine is ready to accept driving the generator and the storage unit.
- Diesel engine – ensures drive of the generator (and the kinetic energy storage) in case of a long grid failure. The engine is preheated in order to guarantee a smooth startup.
- Filter inductor – integrated in series with the utility grid and the loads in order to realize a partial decoupling between the grid side and the load side. This way, the UPS' synchronous machine becomes a very strong energy source for the local loads, able to control the parameters of the supply voltage experienced by the loads. Along with the synchronous machine, the inductor behaves as a filter (using the voltage divider principle), reducing voltage deviations at the grid towards the loads and diminishing current harmonics drawn by the loads towards the utility grid.

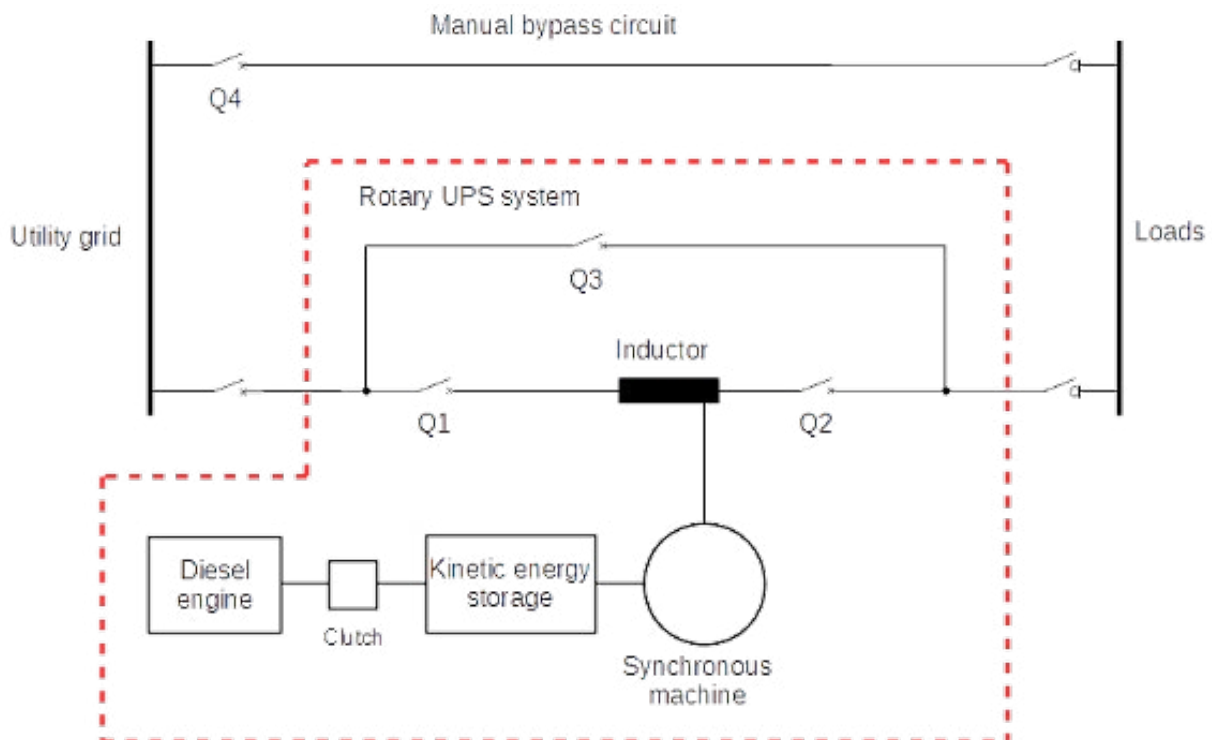


Figure 2: classical rotary UPS topology

- Power panel – this consists of the connections and circuit breakers required to offer a continuous and secure power supply to the critical loads. Usually, the following circuit breakers are included:
 - Grid-side (input) circuit breaker (Q1): disconnects the UPS (and the critical loads) from the utility grid in case the grid voltage does not meet the requirements for supplying the UPS. This breaker also trips in case of a short-circuit upstream of the UPS.
 - Bypass breaker (Q3): in case of an overload condition or a failure of one of the components of the drive train (synchronous machine – kinetic energy storage unit) during normal operation, the loads' power supply is seamlessly transferred to the utility grid (using the bypass circuit). This option is only available if the grid is present and within the voltage and frequency tolerances for supplying the loads. The bypass circuit is also used during startup of the UPS system.
 - Load-side (output) circuit breaker (Q2): controls the (dis)connection of the synchronous machine to the loads (e.g. during transitions between bypass mode and normal operation). In case of a short-circuit downstream of the UPS system, circuit breaker Q2 might trip.



(Photo 3 - DRUPS systemLuminus Solutions)

The main advantages of a classical rotary UPS system are:

- **Robustness:** the main components are all connected using a common mechanical shaft (with a clutch for connecting the diesel engine), accomplishing a simple, reliable and robust system.
- **Integrated system:** this type of UPS system contains all necessary components to provide an uninterrupted power supply capable of handling both short and long utility grid interruptions, simultaneously ensuring the voltage quality for the loads is very high. Other systems require a combination of multiple systems in order to guarantee this level of power supply (e.g. a static UPS system with battery backup and a diesel generator).
- **High short-circuit capacity:** this topology is able to deliver a high short-circuit current during emergency operation (as well as during normal operation) in case of a fault downstream of the UPS output. In most cases, this allows keeping the actual settings of the downstream protection devices.

The principal disadvantage is:

- **Modularity:** this type of UPS system is most profitable for high power applications, using a single unit or two parallel units in most cases (principally, 3-8 units can be installed and operated in parallel, in this type of configurations, one often has to deal with very large currents, possibly necessitating connection at high-voltage level).

This type of UPS system can be realized without a diesel engine, but using this topology, the autonomy reduces to 10-15 s at full load. The other specifications and functions of a rotary UPS system remain valid. This configuration is called a ride-through UPS system, offering the advantage of alleviating the cost and space for the diesel engine and its auxiliary circuits (exhaust system, engine cooling, starter batteries, fuel tank and piping...). The most important drawbacks of a ride-through UPS system are the modularity and the lack of a long-term energy source.

For mobile UPS systems, the following aspects must be taken into account:

- During transport and installation, shocks should be avoided, in order not to damage the bearings and the kinetic energy storage unit. Measures to prevent rotation of the moving components are taken, as well as measures to avoid damage to the vibration dampers supporting the diesel engine, kinetic energy storage unit and the synchronous machine.
- The installation may comprise one or two containers, mainly depending on the UPS's rated power. The aggregate is always mounted in one container (as these components are mechanically connected), but some of the auxiliary systems (dry

cooler, electrical panels,...) may have to be moved to a second container. Some components should be mounted after installation of the system on the company site, e.g. the exhaust outlet is usually not mounted during transport in order to limit the height to that of a standard container.

- The mobile UPS system has a daily fuel tank, typically capable of running the system in islanded mode for 1-3 hours at full load. In case a company requires a higher autonomy, an additional fuel tank must be installed on site. A connection to the UPS' fuel circuit must be made (using the necessary pumps, valves and control system to supply fuel from the external tank to the daily fuel tank in case the latter runs empty).

DRUPS systems without integrated diesel engine

An alternative to the DRUPS systems described in the previous chapter are the rotary UPS systems without integrated diesel engine. The configuration, lay-out, operation and advantages/disadvantages of these systems are very similar to those of the classical DRUPS system, apart from the absence of the diesel engine, which allows the UPS system to autonomously protect the power supply during long outages (exceeding the autonomy provided by the kinetic energy storage). Due to the absence of the diesel engine, this UPS system has a lower cost (CAPEX and OPEX) and smaller footprint.

This rotary UPS system without integrated diesel engine offers a cost-effective solution for companies who:

- Suffer only from short voltage dips/interruptions (typically 10s or less) – in this case, the energy stored in the kinetic accumulator is sufficient to supply the critical loads during the outage.
- Already have a diesel generator on-site, with sufficiently large power to supply the UPS system. In this case, the UPS system can be integrated downstream of the diesel generator and the automatic transfer switch (ensuring automated transfer between grid supply and generator supply in case of a grid outage and return of the grid voltage). Attention must be paid to the diesel generator start-up time: the time between the start-up command to the diesel generator and the stabilization of the generator output voltage must be sufficiently short (typically 8-10s, depending on the autonomy present in the kinetic energy storage).

This UPS system can be delivered with a soundproof enclosure, or integrated in a container or custom-built enclosure, depending on the company specifications. Options include amongst others automatic greasing of the bearings and vibration monitoring, ensuring a close follow-up of the condition of the installation to minimize the risk of unforeseen damages and defects. Various communication protocols are available to provide data exchange with the company supervision system.

The necessary supplies, controls and supervision are included in the electrical panels which are part of the UPS assembly.



(Photo 4 - IEM UPS)



“Luminus Solutions specializes in the more difficult challenges, for companies where the stakes are really high if something were to go wrong. So there’s a lot of engineering involved and it absolutely has to work for sure. It’s rarely just plug and play. But we have a good match between top-quality machinery and a team that has a lot of experience with it.”

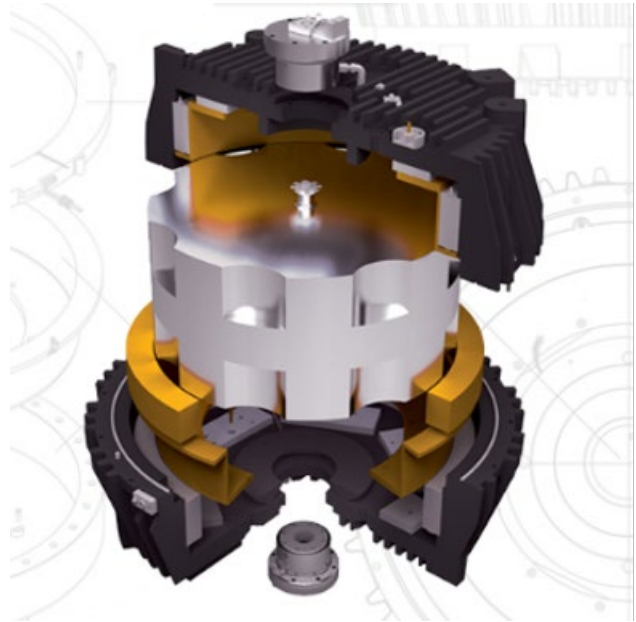
**Patrick Steegmans
Business Unit Director Power Quality
Luminus Solutions**

Hybrid UPS system

A hybrid UPS system combines several elements used in the configurations of a static and (diesel) rotary UPS system previously described.

A typical hybrid UPS system (Figure 3) has one or several flywheels operating as an energy storage unit. The flywheels are not mechanically interconnected with the synchronous machines or the diesel engine, which offers the flexibility to determine and vary the rotational speed independently of the system output voltage magnitude and frequency. These flywheels often operate at a very high speed, optimizing the efficiency of the conversion of kinetic power to electrical power. The flywheels are connected to the utility grid and the loads through back-to-back power electronic converters and possibly a filter inductor. In the grid supply circuit and the bypass circuit, contactors, static switches (using anti-parallel connected thyristors or IGBTs) and circuit breakers or fuses are used to control the power flow and protect the system in case of a short-circuit or failure.

The operating principle strongly resembles that of the line-interactive rotary UPS system previously discussed, the main difference being the absence of an energy source capable of delivering long-term power (the flywheel usually has an autonomy of 15-20 s at rated output power). In order to offer a continuous power supply in case of a long grid outage, a diesel generator (including automatic transfer system for switching between utility grid supply and generator supply) must be installed.



(Photo 5 - Flywheel Active Power)

Upon a grid failure, the flywheel immediately starts supplying power to the loads. The diesel generator starts and after stabilization of its output voltage, the transfer system switches to generator supply. The load is gradually shifted from the flywheel(s) towards the generator. As is the case during normal operation, the flywheel (and the inductor) is used as a power quality filter between the loads and the utility grid. Upon return of the utility grid (waiting for a certain period in order to ensure a stable grid voltage), the diesel generator is stopped, the flywheel temporarily supplies the loads, the grid-side contactor or breaker is closed and the utility grid gradually takes over supply of the loads. Using interconnected circuit breakers, one can alternatively synchronize the generator output voltage to the grid voltage, ensuring a seamless transition from emergency mode to normal operation. This type of system usually results in a slightly higher cost and requires approval of the grid operator.

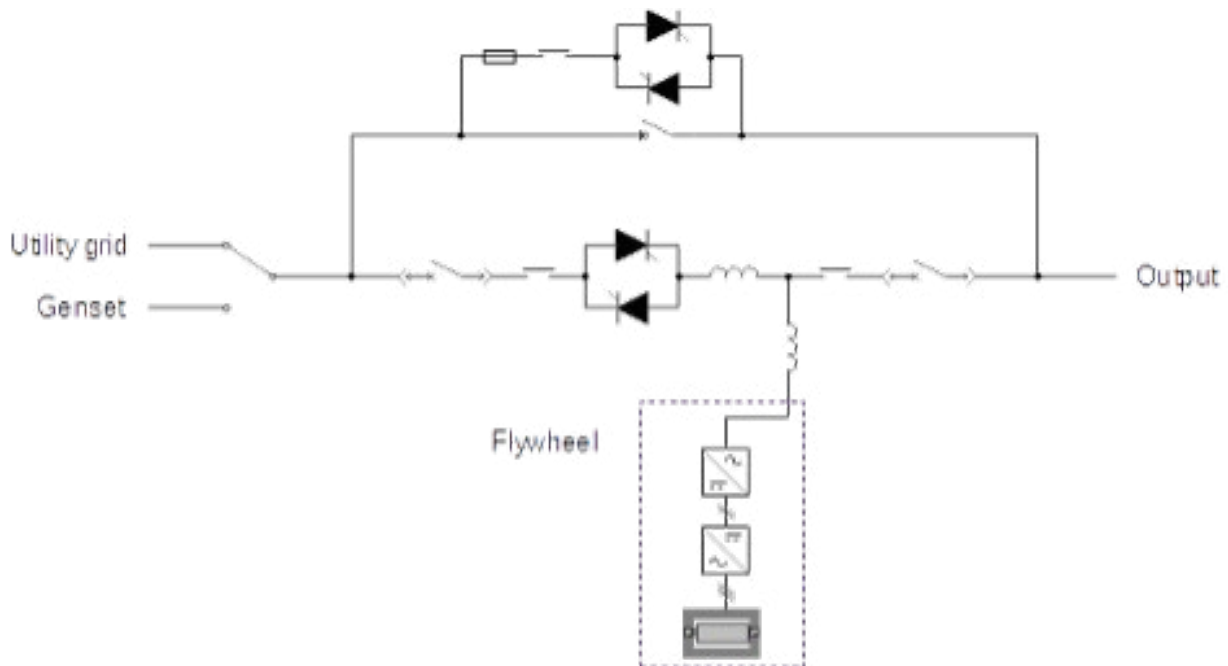


Figure 3: Configuration of a hybrid UPS system with kinetic energy storage

The main advantages of this UPS system are:

- Higher efficiency: the flywheel speed is independent of the 50 Hz output voltage frequency and is not mechanically connected to the generator shaft, allowing optimization in order to reduce the losses (higher rotational speed, special bearings, use of a vacuum environment,...).
- Modularity: the flywheel units are available in relatively low power modules and can be connected into a parallel configuration. This way, the system redundancy can be increased or one can extend the UPS power rating as the critical load power increases.

The most important drawbacks are:

- Robustness: the lack of a mechanical connection between the flywheel and the diesel generator results in a reduced robustness to load steps (because of the lower system inertia). The main components are connected electrically in this configuration.
- Low short-circuit power: the flywheel modules are connected to the grid and loads through power electronic converters, resulting in a low short-circuit capacity during emergency operation (typically only 2-3 times the rated current). This might require adapting the settings of the protection devices or even the installation of additional protection units.
- Reliability: this configuration includes a higher number of components compared to a rotary UPS system, which results in a lower reliability: the higher the number of components connected in series, the more likely a failure resulting in a system shutdown occurs.

When considering a mobile setup for this type of UPS system, the following aspects must be taken into account:

- The flywheel modules are very sensitive to shocks, so measures have to be taken to protect the modules during transport and installation. Protecting the moving parts from rotating during transport might be difficult, as the flywheel is installed in a vacuum enclosure and not easily accessible.
- In order to ensure protection of the critical loads during a long grid outage (exceeding the autonomy of the flywheels), a diesel generator (or another energy source with high autonomy) should be installed, as well as an automatic transfer switch for selecting the source supplying the UPS system (either the utility grid or the diesel generator). It is recommended to install the panel with the transfer switch inside the UPS container. The diesel generator can be installed in a separate container or enclosure.
- In case the autonomy provided by the generator daily fuel tank is not sufficient for the company's purposes, an external tank can be installed. A connection between the external tank and the daily fuel tank must be made, including all required pumps, valves and controls for supplying the daily fuel tank before it runs empty.
- The UPS enclosure should be equipped with the necessary auxiliary circuits to allow correct and continued operation – most importantly ventilation and air conditioning.

Diesel generator

A diesel generator consists of the following components:

- Synchronous machine, operated as a generator.
- Diesel engine: mechanically connected to the generator and started upon a grid outage (given a certain period of grid voltage unavailability, a micro-interruption usually does not result in an engine start). The engine is preheated in order to ensure a smooth start.
- Automatic transfer switch: this system comprises two breakers (one for the grid supply, the other for the generator) with common controls. Upon a grid failure, the transfer system orders the diesel engine to start. After stabilization of the generator output voltage, the system connects the loads to the generator. Upon return of the utility grid voltage, the system switches back to the grid. This transfer system can be realized using a changeover switch (in which case the loads experience a brief interruption at each switchover) or two motorized circuit breakers or load switches (in which case the loads are only interrupted during a transfer from grid supply to generator supply).



(Photo 6 - Diesel generator Europower)

It is important to note that a diesel generator is not a UPS system: it does not perform any filtering of the utility grid voltage during normal operation, it only starts after the grid connection is lost, resulting in a supply interruption for the loads connected directly downstream of the generator output. Certain types of loads allow for a temporary interruption of the supply voltage and do not require UPS filtering and compensation – for these loads, a diesel generator is a sufficient solution for protecting them against long grid outages. Often, a diesel generator is combined with a static or hybrid UPS system, in order to supply the UPS system in case of a long grid outage (exceeding the autonomy provided by the UPS' storage unit, typically batteries or flywheels).

A mobile diesel generator is usually installed in a soundproof enclosure, equipped with all necessary auxiliary circuits (ventilation, engine radiator, daily fuel tank and supply circuit to the engine, starter batteries, exhaust circuit and silencer...) and fit for outdoor installation.

Comparison of the different UPS technologies

This chapter briefly presented the most important UPS technologies, with their main advantages and drawbacks as well as the principal issues for a mobile configuration of each UPS technology.

Generally, the following conclusions can be drawn:

- The most robust technologies are the most suitable for a mobile configuration: diesel generators and DRUPS systems are generally more suited than hybrid UPS systems. The latter are more sensitive to shocks and environmental conditions during transport.
- For low-power applications (300 kVA or smaller), static or hybrid UPS systems are easier to deploy (possibly combined with a diesel generator for protection during long outages), as they are available in smaller modules compared to a DRUPS system. For high-power applications (1000 kVA or higher), the DRUPS system offers the advantage of a compact installation, integrating all necessary components for providing an uninterrupted, high-quality power supply (able to ride through short and long grid outages as well as to filter grid-side disturbances towards the loads) on a small footprint. The total cost for a DRUPS system tends to be lower than that of static and hybrid UPS system for high power applications (certainly for powers > 2 MVA).
- The efficiency of a hybrid UPS system is higher than that of a DRUPS system or static UPS system, certainly in case the load power is smaller than 50% of the UPS rated power. Due to its modular configuration, static UPS systems usually have a higher efficiency for partial load than a DRUPS system – for load powers between 70% and 100% of the UPS rated power, DRUPS systems and static UPS systems generally have a similar efficiency.
- Static UPS systems with battery energy storage are the most sensitive for environmental conditions, certainly the ambient temperature. Batteries require a very accurate control of the temperature inside the enclosure, which makes it difficult to design a mobile system suitable for deployment throughout the year, for a wide region (this yields a wide range of possible temperature conditions, which usually results in a high system cost in order to implement a sufficiently rated cooling system). The battery container needs to include the necessary circuits to protect the enclosure and the company site from possible contamination, fire, explosions... (leakage trays for containing any spilled battery acid, evacuation measures for battery gases,...).
- A DRUPS system is usually installed in a single container or enclosure (except for high-power applications), while the other technologies often require two or more containers or enclosures (one or two for the UPS system and its energy storage, one for the diesel generator). In case multiple enclosures must be installed on site, the intermediary space must be sufficiently large in order to avoid a negative impact on ventilation and cooling, for instance: One should avoid installing the cold air inlet of one container next to the hot air outlet of another container to prevent overheating.

- The air inlets and outlets should be free, not blocked by the other enclosures or adjacent buildings.
- A DRUPS offers the advantage of being able to supply a high short-circuit current during emergency operation (in absence of the utility grid), whereas the other UPS technologies usually have a low short-circuit current during emergency operation. A high short-circuit current allows selective tripping of the protective device closest to the fault within the time frame demanded by the national electrical code. If the faulty section is not disconnected in time, all loads by the UPS system will experience a strongly reduced supply voltage for an excessively long time, which is not beneficial for correct and continuous operation. Also, the UPS systems typically can only deliver this short-circuit current for a limited period of time – if this time frame passes without tripping of a circuit breaker, the UPS system will shut down and the loads will experience an interruption.
- When positioning the diesel generator, the exhaust should not be positioned in close proximity to the air inlet of the other containers. The air inlets and outlets should be free, not blocked by the other enclosures or adjacent buildings.
- A DRUPS offers the advantage of being able to supply a high short-circuit current during emergency operation (in absence of the utility grid), whereas the other UPS technologies usually have a low short-circuit current during emergency operation. A high short-circuit current allows selective tripping of the protective device closest to the fault within the time frame demanded by the national electrical code. If the faulty section is not disconnected in time, all loads by the UPS system will experience a strongly reduced supply voltage for an excessively long time, which is not beneficial for correct and continuous operation. Also, the UPS systems typically can only deliver this short-circuit current for a limited period of time – if this time frame passes without tripping of a circuit breaker, the UPS system will shut down and the loads will experience an interruption.

Application of mobile UPS systems

This section presents several cases in which a mobile UPS system is a suitable solution for protecting a company's critical loads. First some general requirements and specifications for installing a mobile UPS system are discussed. Next, various cases for integrating a mobile UPS system are presented.

Mobile UPS installation requirements

In order to enable integration of a mobile UPS system in a company's electrical infrastructure, the following aspects need to be taken into account:

- Available space:
 - The UPS system (and diesel generator, depending on the type of UPS system and the company's requirements for power protection) must be installed on a flat and stable surface (preferably concrete), able to support the total weight.
 - Sufficient free space around the UPS enclosure(s) must be available, e.g. for optimal air introduction and evacuation, for enabling entrance and maintenance to the enclosure ...
 - Preferably, the distance between the UPS system, the utility grid supply panel and the critical load distribution panel(s) is limited. Excessive cable lengths can result in large voltage drops and high losses.
- Available electric panels (see Figure 4 for an example of the required electrical installation):
 - The UPS systems described in this paper all have the same lay-out: the utility grid is connected to the UPS system as an input, the output of the UPS system is connected to the critical loads.
 - The company must have a free circuit breaker on an electrical panel upstream of the critical loads, allowing connection of the cables supplying the UPS system. It must be possible to change the protection parameters of this circuit breaker to obtain correct protection of the cables, taking into account the UPS specifications (power usage, possible inrush currents...). We also recommend having a manual bypass circuit for the mobile UPS system.
 - In order to distribute the UPS output power to the critical loads, a free connection (equipped with a load switch or circuit breaker) should be available on each distribution panel to be supplied by the UPS system.

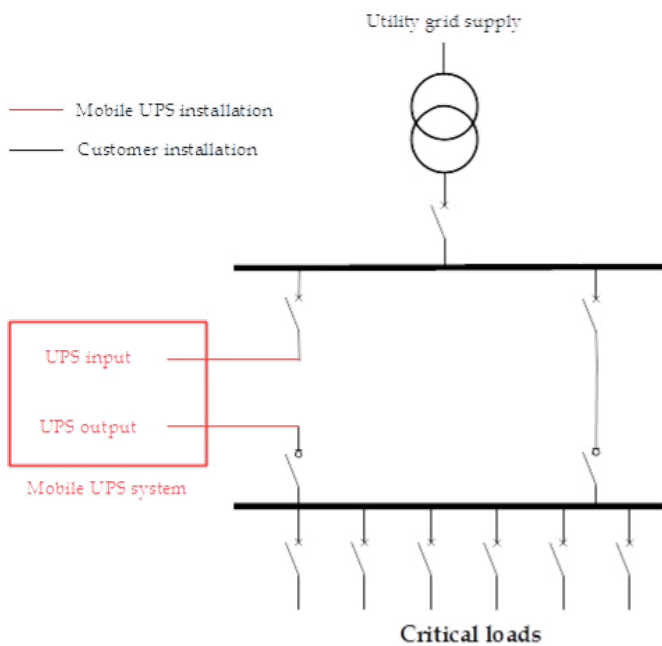


Figure 4: Preferred company installation for MUPS integration

- Exhaust gases:
 - During emergency operation, the diesel engine emits exhaust gases. It is important to install the UPS system (or the diesel generator) at a site at which the exhaust gases do not negatively impact the company's operations (for instance near building air inlet, directly adjacent to office buildings).
 - Alternately, in case the company has one or several installations emitting possibly hot or harmful gases, it is recommended not to install the mobile UPS system in the vicinity of these processes, in order to avoid introduction of these gases in the UPS system.
- External fuel tank: in case the autonomy required by the company exceeds the autonomy provided by the mobile UPS' internal fuel tank, an external tank should be installed, including a circuit with the necessary pumps, valves and controls for supplying fuel to the MUPS' internal tank. The connection of this fuel circuit to that of the MUPS should be easy to make.
- Mobile UPS cabling:
 - In order to facilitate the connection of the mobile UPS system to the company installation, it is recommended to install an electrical panel near the UPS installation site. The cabling between this panel and the company's panels is permanent (possibly installed in cable trays or underground basement trajectories). This limits the cable length of the temporary mobile UPS cabling, which is usually not installed inside a cable tray.

The following parameters and information are required for determining the mobile UPS power rating, cabling and circuit breaker settings:

- Maximum load power to be supplied by the UPS (measured or estimated) – a distinction must be made between the active load power (kW) and the apparent load power (kVA). In case the critical loads draw or deliver a significant amount of reactive power (kVAr), this has an important impact on the UPS. Communication of the worst-case power factor is useful for a correct rating of the mobile UPS system.
- Single-line or detailed electrical diagram of the installation – certainly for the connection of the UPS grid supply and the UPS load distribution. Detailed information regarding the circuit breakers and load switches as well as the rating of the electrical panels upstream and downstream of the mobile UPS system are required as well.
- Desired autonomy in case of a grid outage



(Photo 7 - Mobile UPS System Luminus Solutions)

Application cases for a mobile UPS system

This section presents several cases in which integration of a mobile UPS system is useful for protecting the power supply of the company's critical loads:

For in possession of a “fixed” UPS system:

A mobile UPS system can be installed during the revision of the “fixed” UPS system. As a part of the maintenance throughout the lifetime of a DRUPS system, a revision for the synchronous machine and the kinetic energy storage unit are required (typically each 7-10 years). These components usually have to be moved to the revision facility, meaning a temporary unavailability of UPS supply for the critical loads. A procedure for installing a mobile UPS prior to removal of the “fixed” UPS components allows to maintain a UPS-protected power supply for the company. The switchover procedure typically looks like this:

- Installation of the mobile UPS system on the company site, connection of the cables, possibly testing of the mobile system.
- Transfer the “fixed” UPS system to bypass.
- Connection and startup of the mobile UPS system in bypass mode.
- Decommissioning of the “fixed” UPS system – disconnection of the UPS from the company network (grid supply and load distribution)
- Transfer of the mobile UPS system to normal operation

After this step, the mobile UPS protects the critical loads and the “fixed” UPS can be revised.

- In case of a defect or failure of the “fixed” UPS system, a mobile UPS system can be integrated temporarily to allow for inspection and testing of the “fixed” UPS. This reduces the time during which the company's critical loads have to be supplied directly by the utility grid.
- For a temporary increase of redundancy or UPS power: in case a company has a need to temporarily increase the redundancy of the UPS power supply, a mobile UPS system can be installed. Of course, compatibility of the mobile UPS controls with those of the “fixed” UPS systems is required to allow parallel operation of both systems. The company installation must also be rated to accommodate this increased UPS capacity (circuit breaker, cable and panel ratings, selectivity...). It is also possible to install the mobile UPS system in series with the “fixed” UPS systems.

For a company in the process of obtaining a “fixed” UPS system:

In case a company has ordered the installation of a UPS system, the electrical installation (panels, cabling) often has a much lower delivery time than the UPS system itself. In order to reduce the time for obtaining a UPS-protected power supply for the critical loads, a mobile UPS system can be installed after commissioning of the electrical panels and cabling. When the “fixed” UPS system is delivered on site, the mobile UPS system can keep on protecting the loads while the “fixed” system is installed, tested and commissioned. After commissioning of the “fixed” UPS system, the mobile UPS system can be shut down and removed from the site.

For a company without a “fixed” UPS system:

In case the company temporarily requires a protected power supply for (part of) the loads, a mobile UPS system can be installed on site to fulfill this need, provided the necessary conditions for integrating a mobile UPS system are met (see section 0).



(Photo 8 - 1600 kVA mobile UPS Luminus Solutions)

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www.luminussolutions.be

+32 16 76 80 40
info@luminussolutions.be
Bleyveldstraat 9
3320 Hoegaarden

