Overcoming the Instability of the Grid

Piller UK Ltd

Nothing protects quite like Piller

Agenda

- Understanding how the UK grid has evolved
  - The move from centralised to embedded generation
  - The challenges this creates
  - Developments in the Grid
- Site Power Issues
- Fundamental UPS technologies
  - Conversion method
  - Energy storage method
- Understanding redundancy / paralleling / system integration / stabilisation

Technical Manager:
Keith Maclean-Martin

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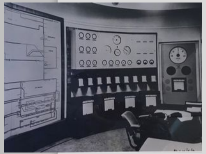
Grid Background

Grid born with 7 major control rooms across the country
1935

National Grid Constructed
1936

First combining of the regions (unauthorised)
1937

275kV 'supergrid' project launched
1950



CEGB established 'to keep the lights on'
1957

400kV 'supergrid' project group established
1961

400kV 'supergrid' construction began
1965

Regional Engineering Departments formed
1970s

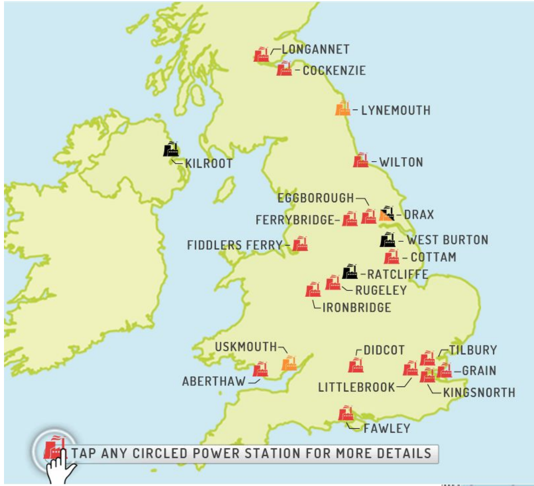
North London's 400kV connection delivered more efficient transmission
1974

Construction began on pumped storage station Snowdonia – 1300MW
1976

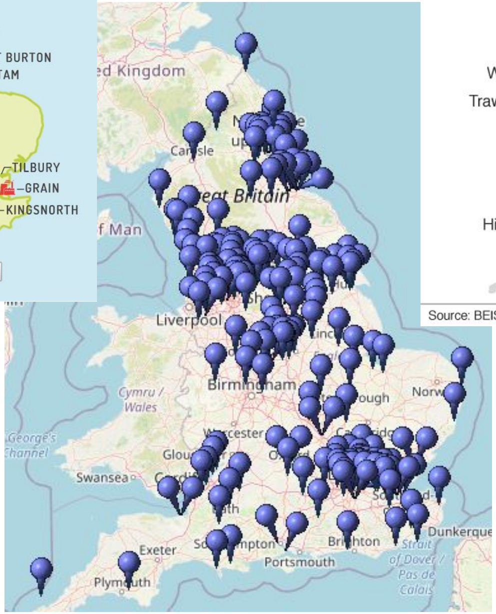
1930s | 1950s | 1960s | 1970s

Grid Background

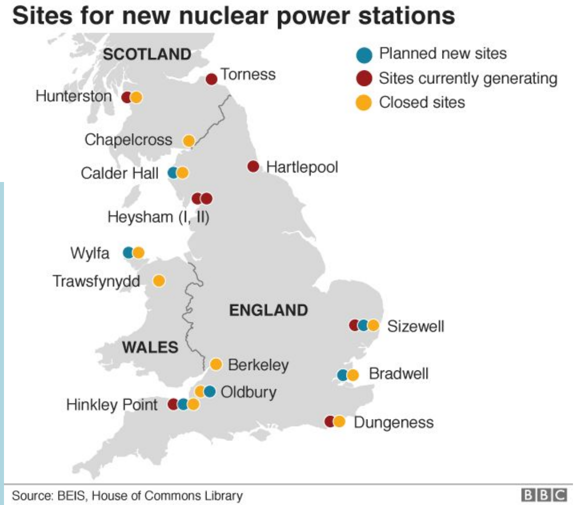
PILLER Power Systems



Coal Fired Power Stations



All Power Stations



Nuclear Power Stations

National Grid Distribution Network

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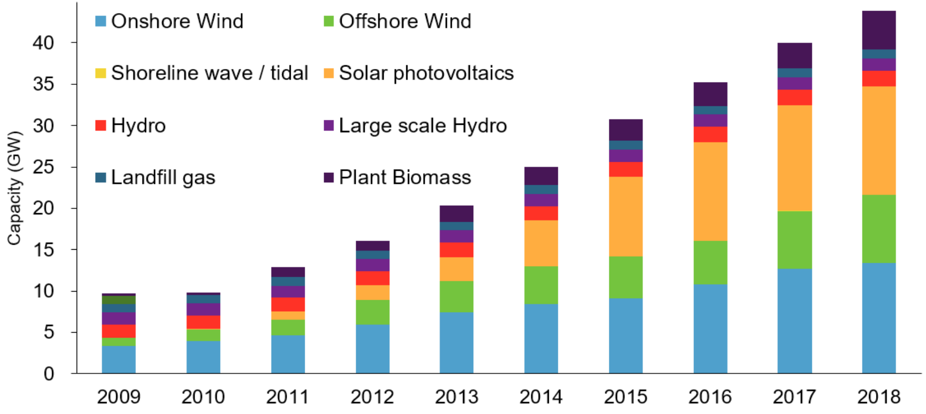
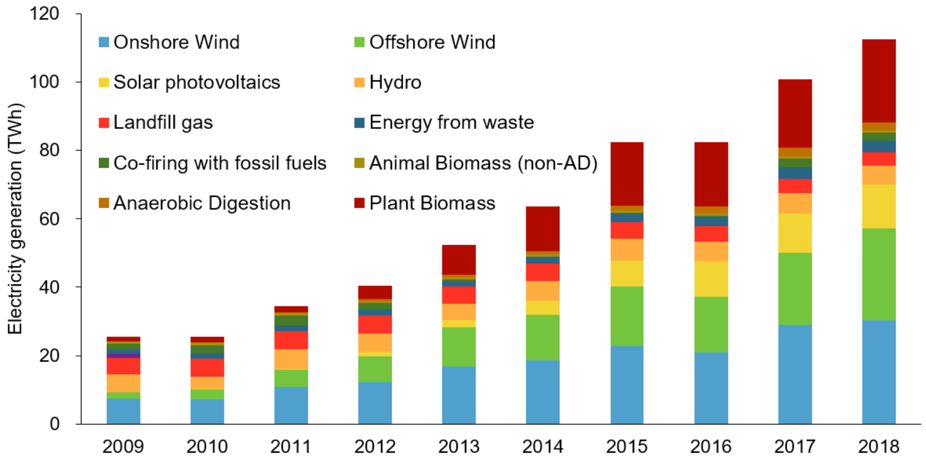
Grid Background

Growth of Renewable Generation

Growth more than 4 fold in the 10 years. Capacity dominated by wind (onshore & offshore), but solar has grown rapidly over the last 5 years.



The generation seen from the install base of solar is still small in comparison due its intermittency and restricted to daylight hours only.



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Grid Background

Wind

Solar

Hydro

Other

Storage

Grid Developments

Demand Side Response

Frequency Response Services

- ❑ Dynamic Containment (New)
- ❑ Dynamic Moderation
- ❑ Dynamic Regulation
- ❑ Mandatory Response Services
- ❑ Firm Frequency Response (FFR)
- ❑ Frequency Control Demand Management (FCDM)

Reserve Services

- ❑ Fast Reserve (FR)
- ❑ Short-Term Operating Reserve (STOR)
- ❑ Demand Turn Up
- ❑ Super SEL
- ❑ BM Start Up
- ❑ Replacement Reserve (RR)

Info taken from: https://www.nationalgrideso.com/industry-information/balancing-services/demand-side-response-dsr

Grid Event

Everything running as expected

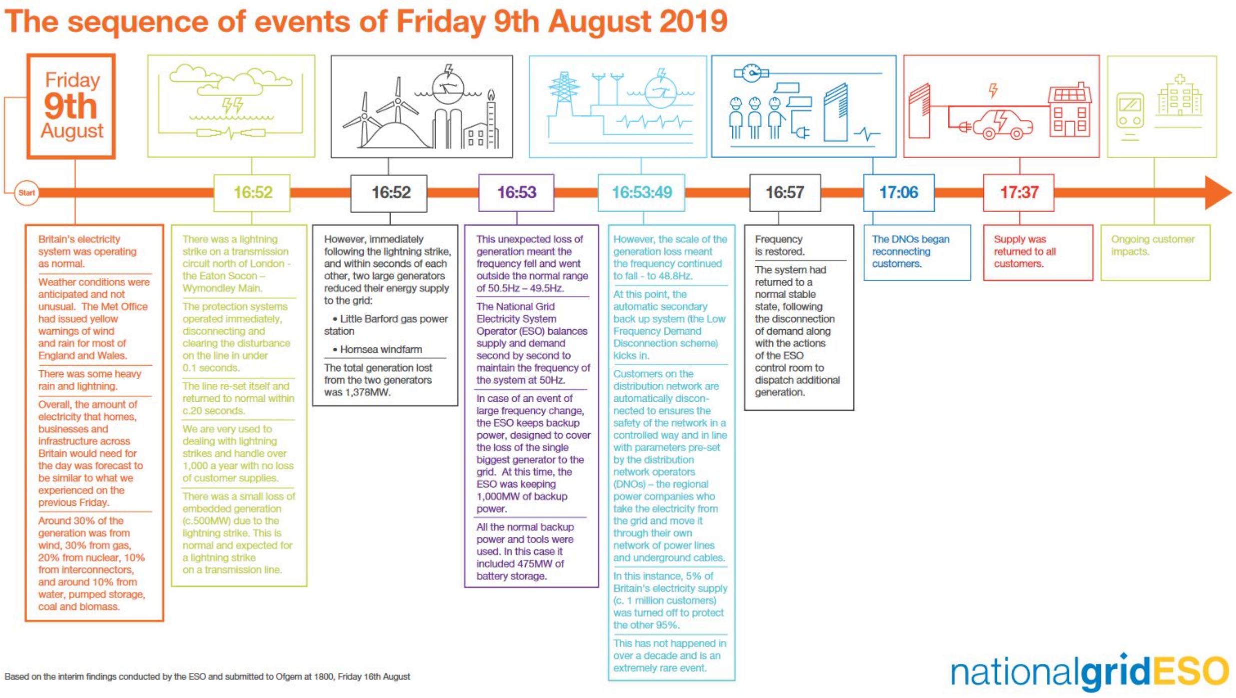
Lightning strike on transmission circuit north of London.

Protection cleared in 1s and returned to normal within 20s – as expected.

Loss of 500MW of embedded generation as a result.

Within seconds, two large generation plants were disconnected – 1,378MW.

Frequency fell outside target range – 50.5Hz-49.5Hz.



ESO keeps backup power to cover single biggest generator on the grid. At this time 1000MW was in reserve.

475MW of battery storage was available.

The scale of incident frequency went to 48.8Hz.

Secondary protection – low frequency demand disconnection scheme.

Disconnections occurred – 5% of homes (c. 1M homes) to save 95%.

An event scene in over a decade.

Frequency restored and systems begin to return to normal.

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Grid Developments

PILLER
Power Systems

Accelerated Loss of Mains Change Programme [ALoMCP]

- EREC G59/3-7 implemented by generation owners by 01 September 2022.
- LoM by vector shift removed
- Rate of Change of Frequency protection (RoCoF) used
- New RoCoF setting 1 Hz/s; definite time delay of 500 milliseconds

LoM Accelerated Loss of Mains Change Programme

ena nationalgridESO

What does this mean….?

- Grid frequency stability reduced
- No early disconnection of distributed generation
- Greater frequency deviations possible (0.5Hz still the target deviation limit)
- More frequent deviations likely

Grid Developments

Fault Current

- Decreased in synchronous generation, reduced fault current.
- Asynchronous sources using static inverters limited to 2-3 x rated current.
- Location of generation changed.
- Protection on the network an issue – grading no longer working.
- Further disruptions at point of use.

Inertia

- Systems calculating real-time value for the Grid.
- Affected by reduced synchronous generation.
- Inverters use PLL control to follow supply offering no immediate support.
- Leading to greater risk of frequency deviations.

Green Inertia Projects

Common Site Supply Issues

Voltage Issues

Outages

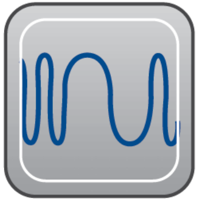
Sags

Surges

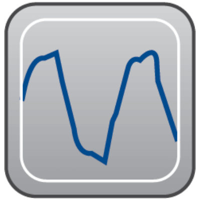
Under-Voltage

Over-Voltage

Frequency Issues



Frequency Deviation



Harmonics

Other Issues

Spikes

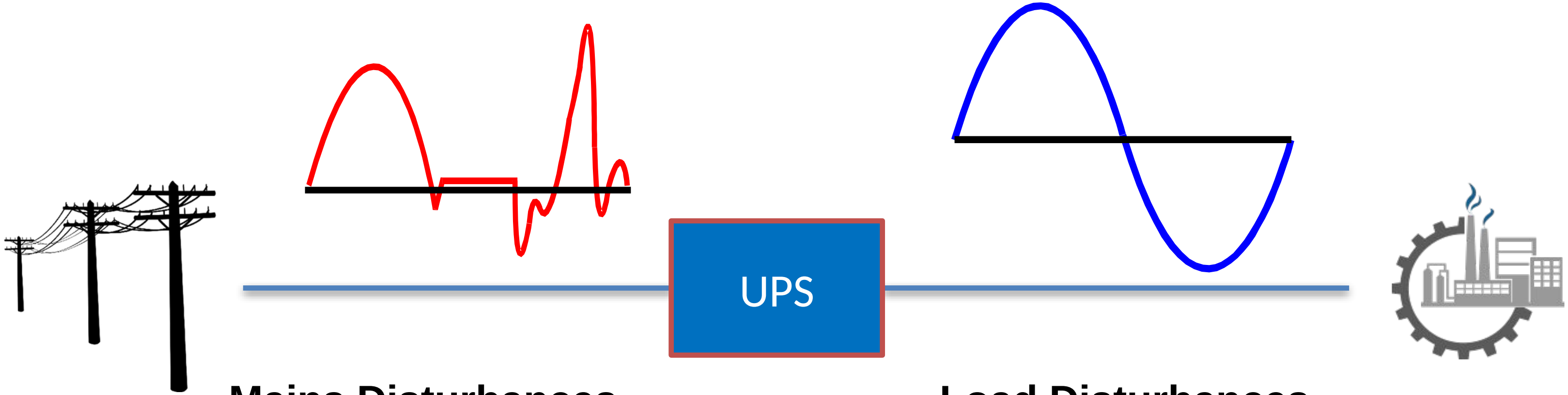
Noise

Transient

Impact….

- Loss of production time
- Product damage
- Equipment damage
- Reputation
- Financial loss

UPS Technology – The need for an Uninterruptible Power Supply



Mains Disturbances

- Short Interruptions
- Total Failures
- Voltage Fluctuations
- Frequency Deviations
- Glitches
- Harmonics

Load Disturbances

- Harmonics
- Transients
- Overloads
- Short Circuits
- Unbalanced Loads
- Load Fluctuations
- System Perturbation

UPS Technology – The need for an Uninterruptible Power Supply

PILLER Power Systems

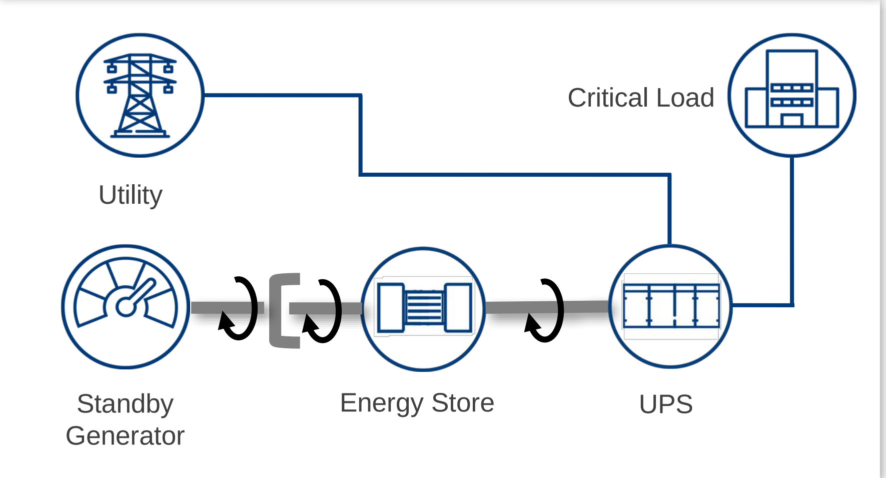
What UPS topology is available in the industrial market?

What are the two fundamental UPS topologies available?

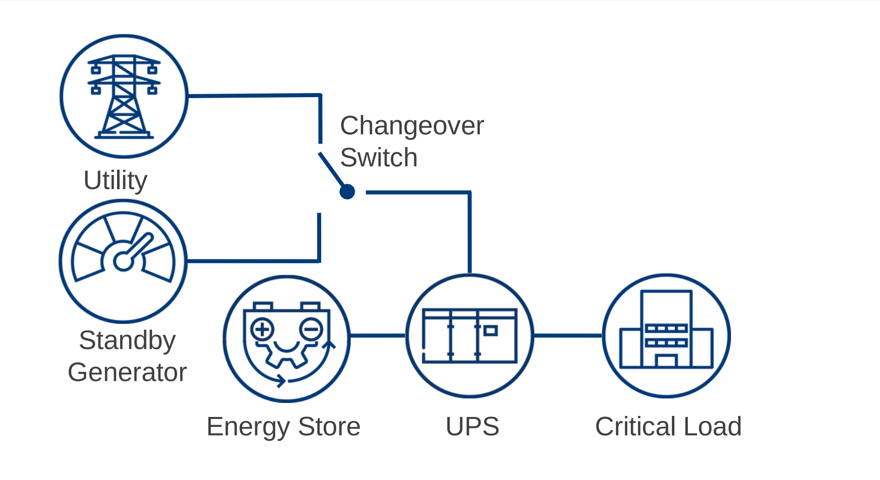
UPS topology is best differentiated by the way in which the energy transfers between storage and UPS

A UPS topology is not defined by the type of energy storage (battery, flywheel, capacitor,...)

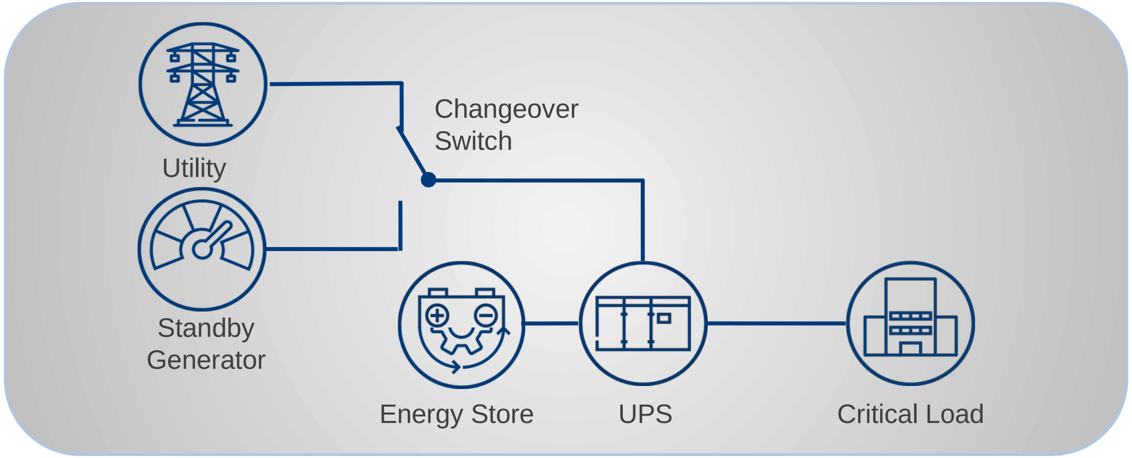
Mechanically Coupled (MC)



Electrically Coupled (EC)



UPS Technology – Electrically Coupled



Synthesized Generation (Static UPS)

- Capacitors
- Simulated waveform
- Conversion of power transfer
- LV applications only
- Cooling provided by electric fans
- Reduced reliability

Natural Generation (UNIBLOCK™)

- Reduced component count
- Larger capacity single units
- No power capacitors to replace
- Natural cooling with no electric fans
- HV & LV integration available
- Very High MTBF

UPS Technology – Comparison

PILLER Power Systems

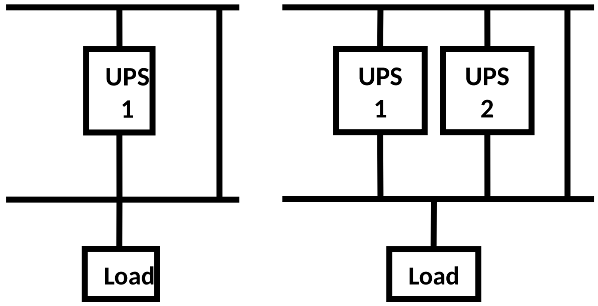
Chemical Energy	Kinetic Energy
 	  
▪ Longer autonomy ▪ Flexible power rating ▪ Low standing losses	▪ Environmentally friendly ▪ Easily determined energy – ▪ No degradation through cycling or age ▪ Long life ▪ Smaller footprint ▪ No major overhauls required ▪ Rapid recharging

UPS Technology – The need for an Uninterruptible Power Supply

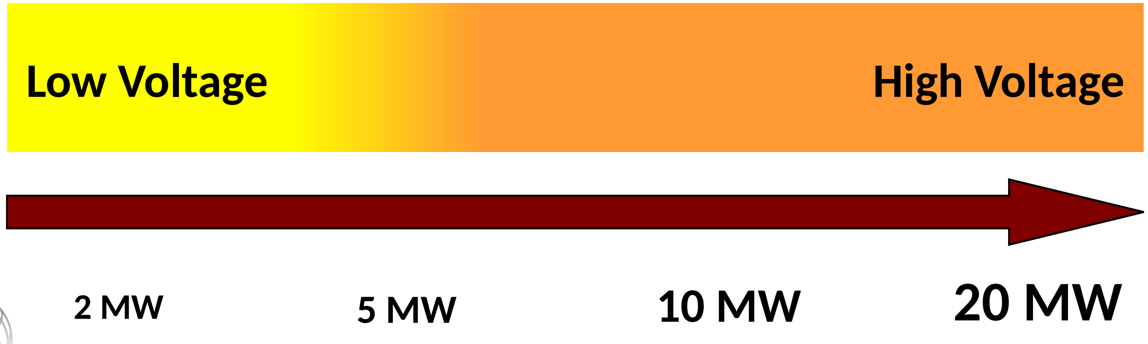
	Mechanically Coupled UPS	Electrically Coupled STATIC	Electrically Coupled UB-V
Energy transfer control	Electro-mechanical converter	Power Electronics/DC Link	Power Electronics/DC Link
Energy storage options	Flywheel	Battery (all types) & Flywheel	Battery (all types) & Flywheel
Backup generator flexibility	Direct Mechanical connection only.	Upstream Electrical connection only.	Upstream, Downstream or Direct Electrical connection.
Operating voltage flexibility	Low and High Voltage	Low Voltage	Low and High Voltage
Capacitive filtering (capacitors)	Not required.	Yes	Not required.
BESS compatibility	Not possible.	Possible only when modified for bi-directional power flow.	Possible
Reliability	Medium	Low	High
Maintenance	High	Medium	Low
Power ratings – single unit	> 3MW	300kW	>3MW

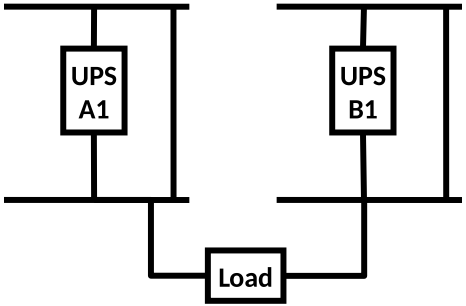
Redundancy - Considerations

- Increases reliability of a system
- Redundancy ensures continuity of service
- The more redundancy a system has, typically the lower the chance of failure
- Allows maintenance without loss of protection
- Redundancy introduces stranded capacity



Increasing the UPS power supply by direct paralleling





Redundancy – Integrated Generation

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<tr><th>Upstream – Typical arrangement</th><th>Embedded – (DRUPS)</th><th>Downstream – Exclusive to Piller</th></tr>
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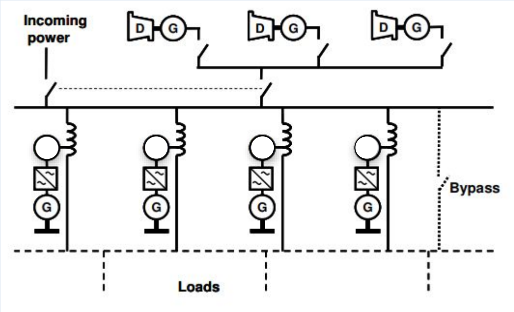
<td>
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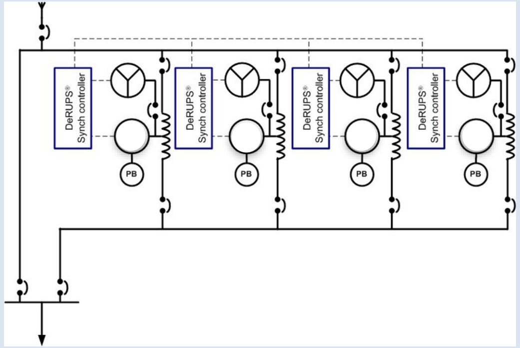
<td>
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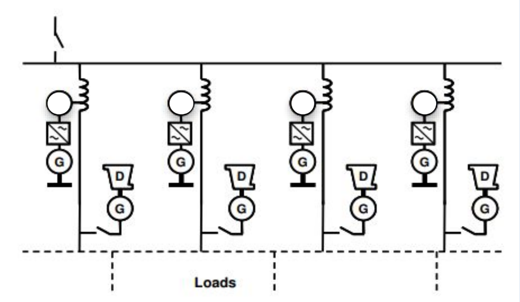
<td>
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<td>•Generators able to permanently supply loads via UPS bypass
•Maintenance on diesels can be carried out independently of UPS
•Number of diesel engines can differ from number of UPS
•High fault current contribution to grid
•Export excess power</td>
<td>• Number of UPS/Diesel engines equal
• Simple integration at HV with UPS alternator
• Maintains resilience
• Typically mechanically coupled
• Reduces ride through time</td>
<td>• Allows charging of the energy store
• Allows for export of power and stabilization of CHP applications
• Reduced losses
• Generators operate as real power machines
• Short break load solutions possible</td>
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Case Study – CHP Application

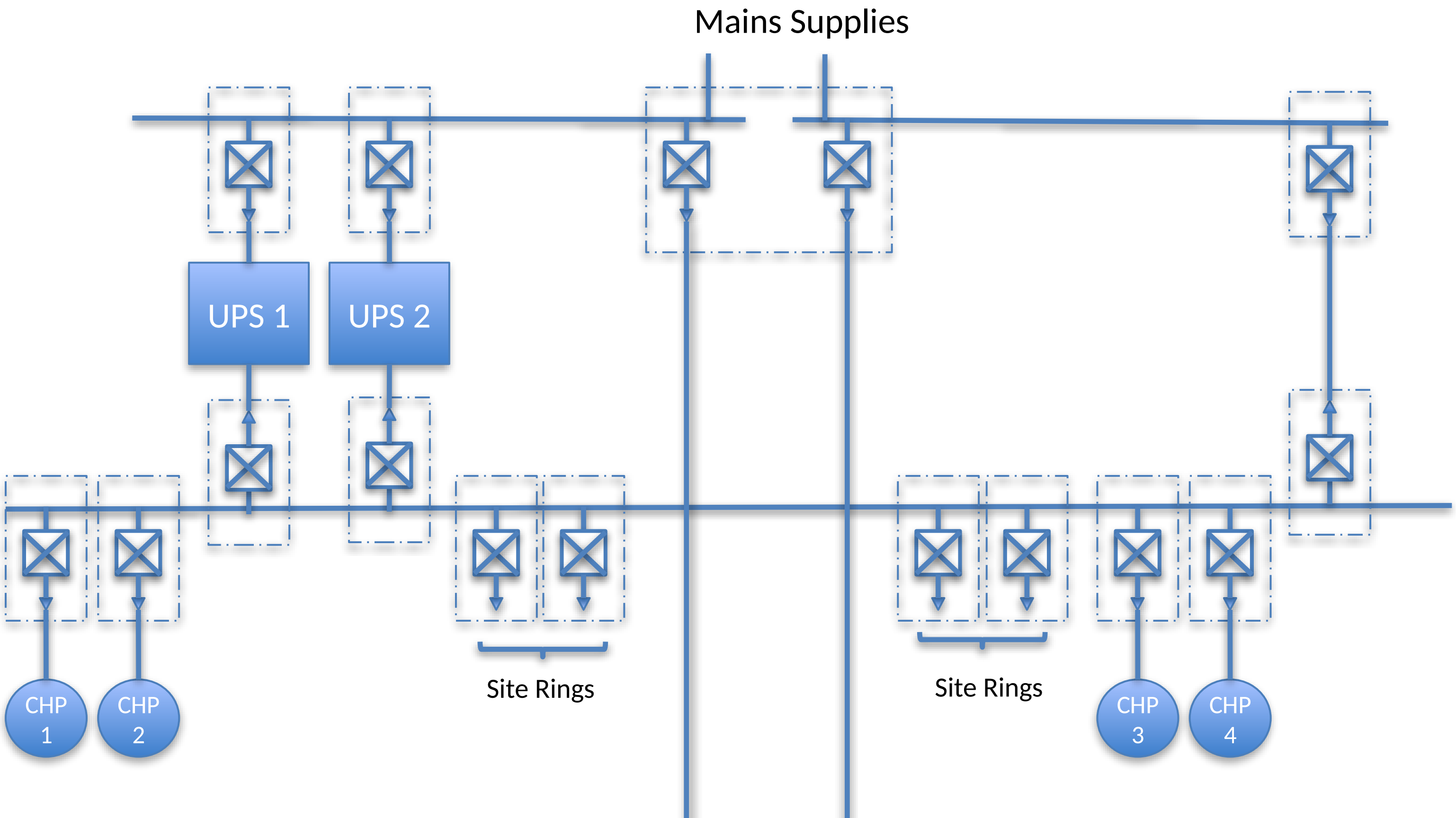
Customer with a CHP application requires stabilisation

- Customer considering "Green" solutions with CHP or has legacy embedded generation.

- Solution (UNIBLOCK™ UPS with POWERBRIDGE™)
    - Allows Bi-directional power transfer
    - Voltage regulation and reactive current compensation
    - Filters out transients
    - Generated Revenue streams
        - Export of power to the grid (STOR)
        - Enhanced Frequency Response (EFR)
        - Peak price management (TRIAD)

- POWERBRIDGE™ combines with CHP to enable Island Operation, reducing the risk of nuisance tripping.

Case Study – Stabiliser Overview



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Agenda

PILLER Power Systems

- ✓ Understanding how the UK grid has evolved
  - The move from centralised to embedded generation
  - The challenges this creates
  - Developments in the Grid
- ✓ Site Power Issues
- ✓ Fundamental UPS technologies
  - Conversion method
  - Energy storage method
- ✓ Understanding redundancy / paralleling / system integration / stabilisation

Q & A

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