Microgrid

Presenter: Victor Dunand

Agenda

1. Key driver for microgrids?

2. What is a microgrid?

3. Frequently asked questions answered
   - Impact of DER on Electrical network
   - Control strategy
4. 3 Case studies
5. Summary

Presenter: Victor Dunand

Key drivers

Cost

Sustainability

Reliability

Presenter: Victor Dunand

What is a microgrid?

Presenter: **Victor Dunand**

Definition microgrid

A **microgrid** is a local electrical distribution system with **Distributed Energy Resources** operated in a coordinated way so to provide one or more of the following capabilities:

- to manage the site **Energy consumption** and **Demand**
  Peak shaving | Shifting | etc.
- to provide **services** to the **grid** and to the **market**
  Demand response | Ancillary services | etc.
- to increase **resiliency**
  Islanded operation | increase back-up generation availability | etc.
- to integrate **cost-effective energy sources**
  Grid code compliance | Export control | Self-consumption

Presenter: Victor Dunand

Distributed Energy Resources

The Institution of Engineering and Technology

Distributed energy resources (DERs) are **electricity-producing resources** or **controllable loads** that are directly connected to a local distribution system.

DERs can include:

- solar panels
- wind turbine
- combined heat and power plants
- electricity storage
- generating set
- electric vehicles
- controllable loads: HVAC, industrial processes, etc.

Source: http://www.ieso.ca/

Presenter: Victor Dunand

Three types of microgrid

The Institution of Engineering and Technology

On-site renewables, energy storage and power generation facilities utilized in parallel with grid

Microgrid will generate energy from local sources in the case of a grid outage OR other external event which makes local energy more desirable

Microgrid will generate energy from local source

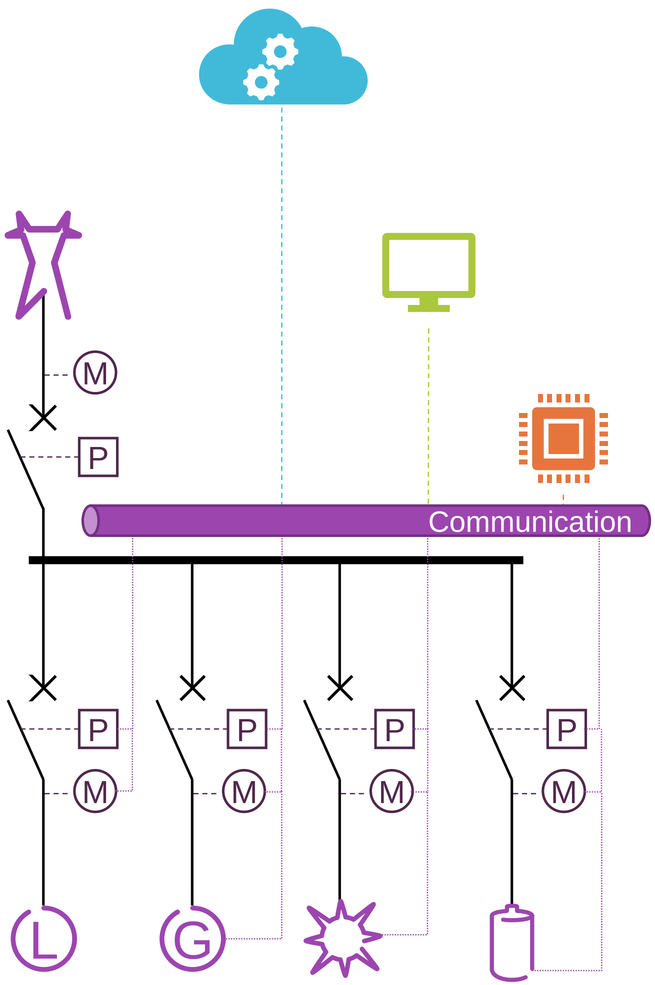
Grid-tied

Island-able

Off-grid

Presenter: Victor Dunand

Microgrid Architecture



Cloud services

- Energy Management
- Advanced Algorithm
- Global data collection
- Connection with 3rd parties

Supervision, HMI & Data Management

- Data acquisition
- Alarming, Trending and reporting
- Remote and local interfaces

Microgrid Control

- Real time edge control
- Power Management
- Grid-connection management

Electrical Infrastructure

- Protection schemes
- Power Quality & Metering
- Switchgear and transformer

Distributed Energy Resources

- Electricity generating sources
- Flexible loads

Presenter: Victor Dunand

Something ‘New’

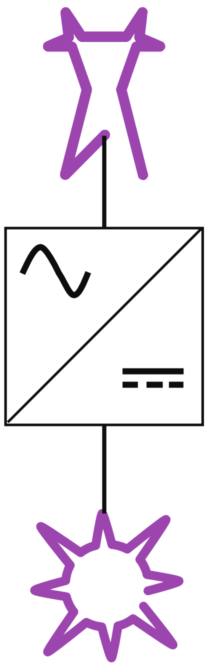
Solar PV and Battery Energy Storage System

Presenter: Victor Dunand

Solar PV Inverter

The Institution of Engineering and Technology

A solar inverter or PV inverter, is a type of electrical converter which converts the variable **direct current** (DC) output of a photovoltaic (PV) solar panel into a utility frequency **alternating current** (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.



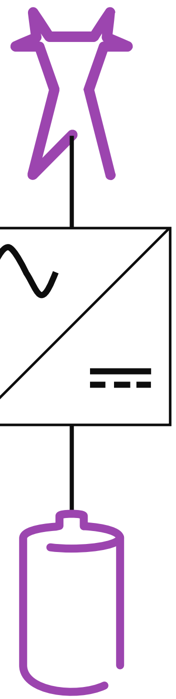
Presenter: Victor Dunand

Source: https://en.wikipedia.org/wiki/Solar_inverter

Battery Energy Storage Inverter

The Institution of Engineering and Technology

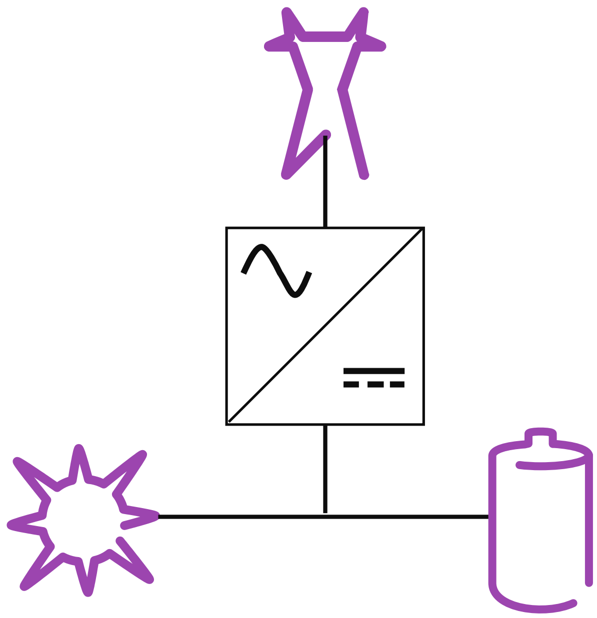
Inverters in Battery Energy Storage Inverter are electrical converter which allows the bi-direction conversion of electricity from/to d**irect current**(DC) from/to **alternative current**(AC) so to charge or discharge the batteries into a commercial electrical grid or used by a local, off-grid electrical network.



Presenter: Victor Dunand

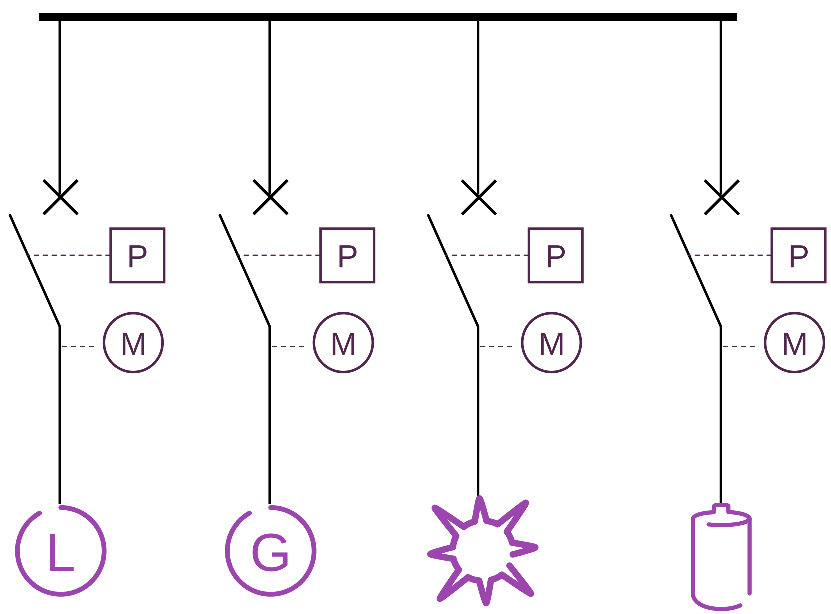
Hybrid inverter

Hybrid inverters allow the connection on the direct current (DC) side of solar panels and batteries so that the battery can be charge directly from the solar panels.



More on inverters

	Grid-tied 'Stiff' inverter	Grid-forming inverter	Virtual Synchronous Generator
Grid-connection	Yes	Yes	Yes
V and f reference	-	Yes	Yes
Parallel operation with other generating units	-	-	Yes



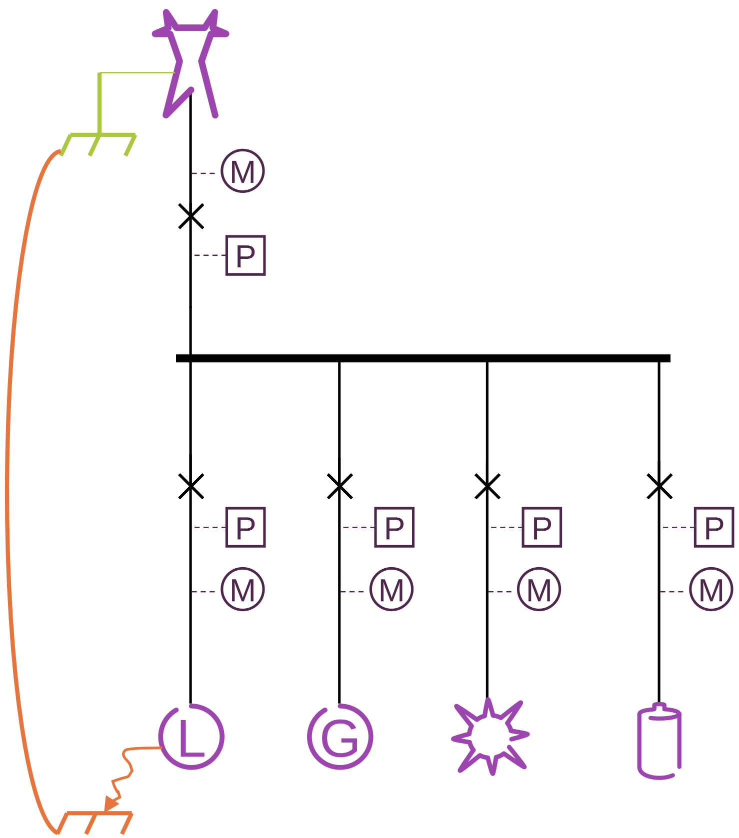
Presenter: Victor Dunand

Frequently Asked Questions Answered

Presenter: Victor Dunand

Earthing regime

Grid-tied

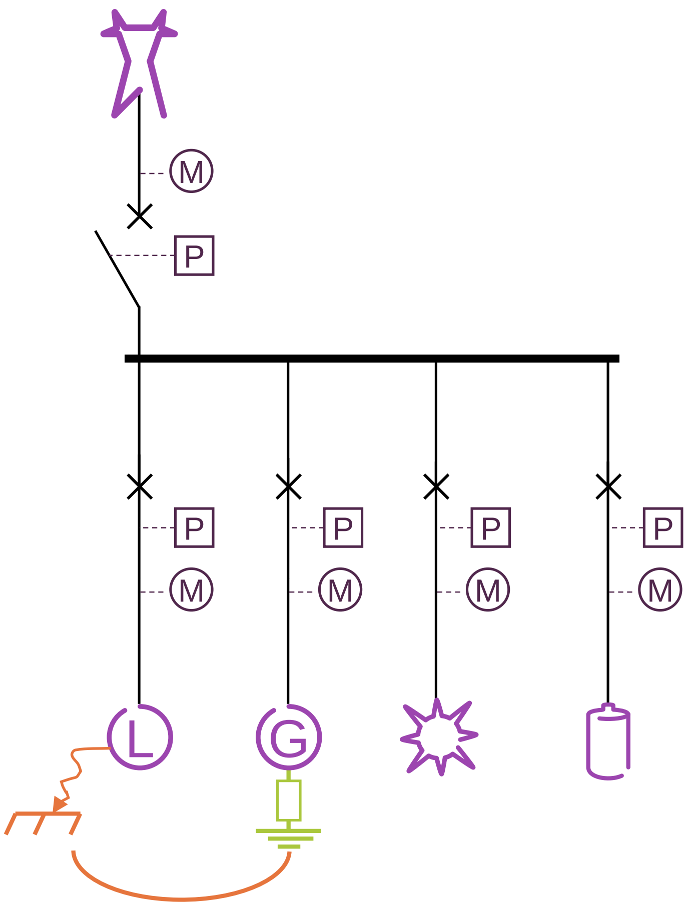


- Grid provide Earth reference
- Earth Faults are ‘captured’
- Protection system can detect residual current

Presenter: Victor Dunand

Earthing regime

Islanded Genset back-up



- Earth reference provided through the generator earthing resistor
- Earth Faults are ‘captured’
- Protection system can detect residual current

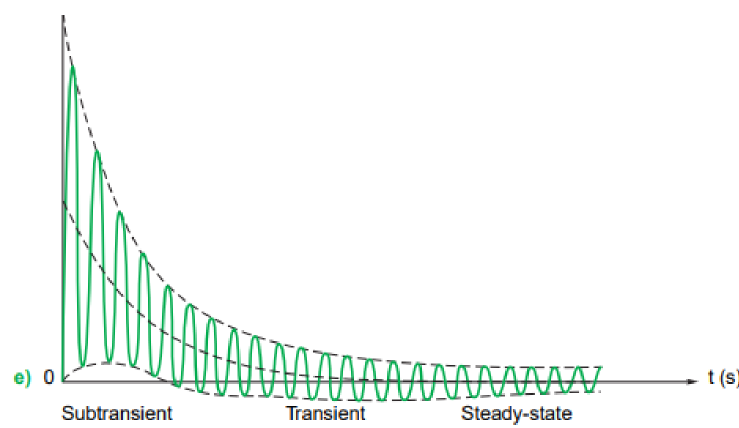


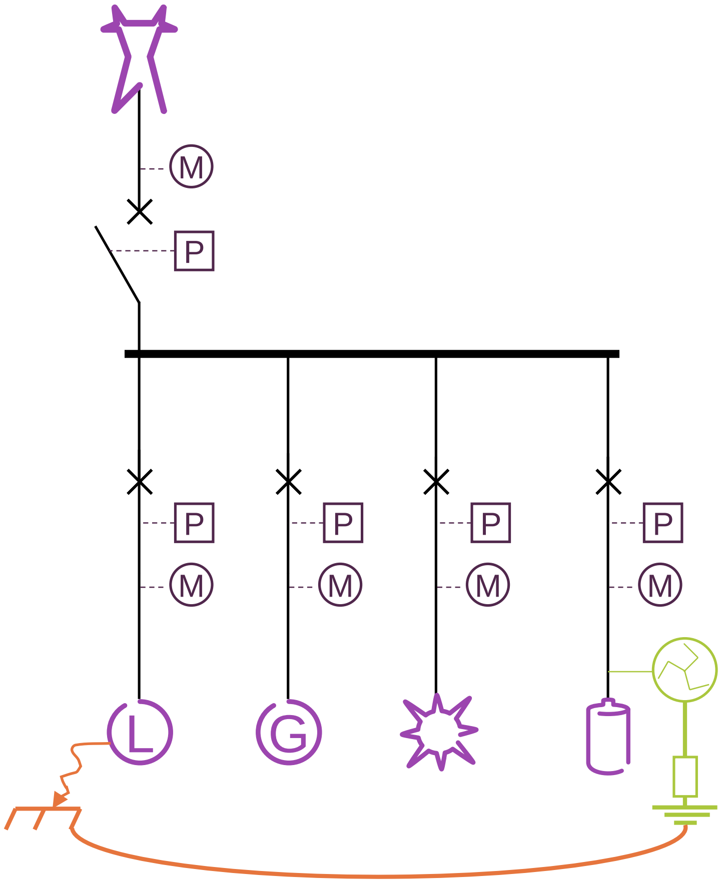
Fig. 10 : Total short-circuit current i_{sc} (e), and contribution of its components:

Source: Cahier technique no. 158 –
Calculation of short-circuit currents – Schneider Electric

Presenter: Victor Dunand

Earthing regime

Islanded BESS



- Earth reference provided through the earthing transformer
- Earth Faults are ‘captured’
- Protection system can detect residual current

1.1 In < If < 2.8In

Presenter: Victor Dunand

Control strategy

Problem

$$C_{ost} = E_{lectricity\ consumption} \times P_{rice} - R_{evenue}$$

$$C = E(_{load,\ DER}) \times P(_{demand,\ location\ ,time}) - R(_{time})$$

load → f(time)

DER → f(time, weather)

Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

What does this tell us?

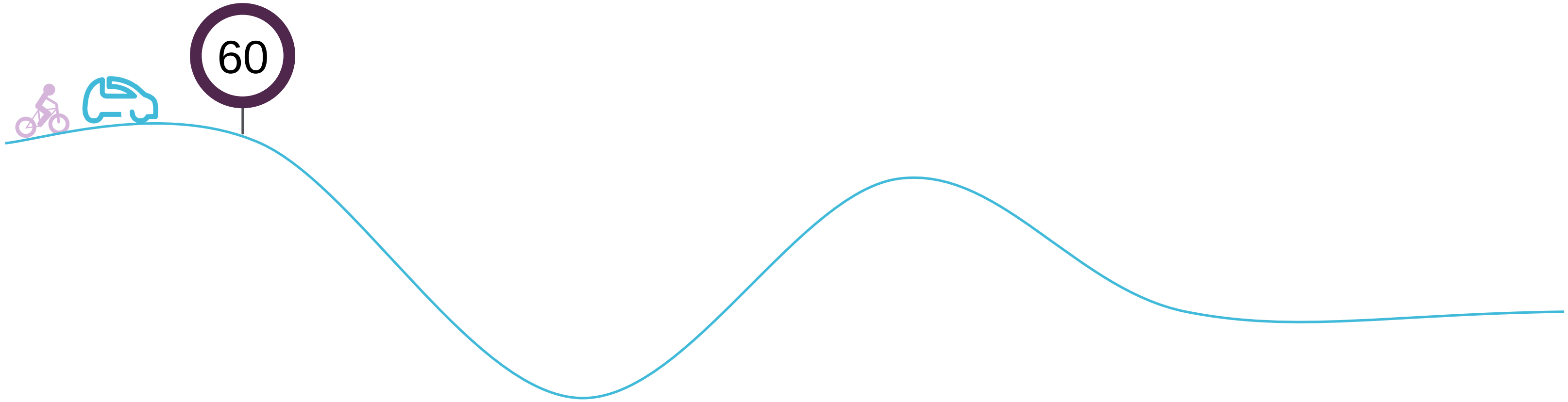
The Institution of Engineering and Technology

- Need to predict and forecast the future.
- Need to use cost effective generation.
- Need to optimise the use of DER.
- Need to be able to access the potential remaining value.

Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

Classic control



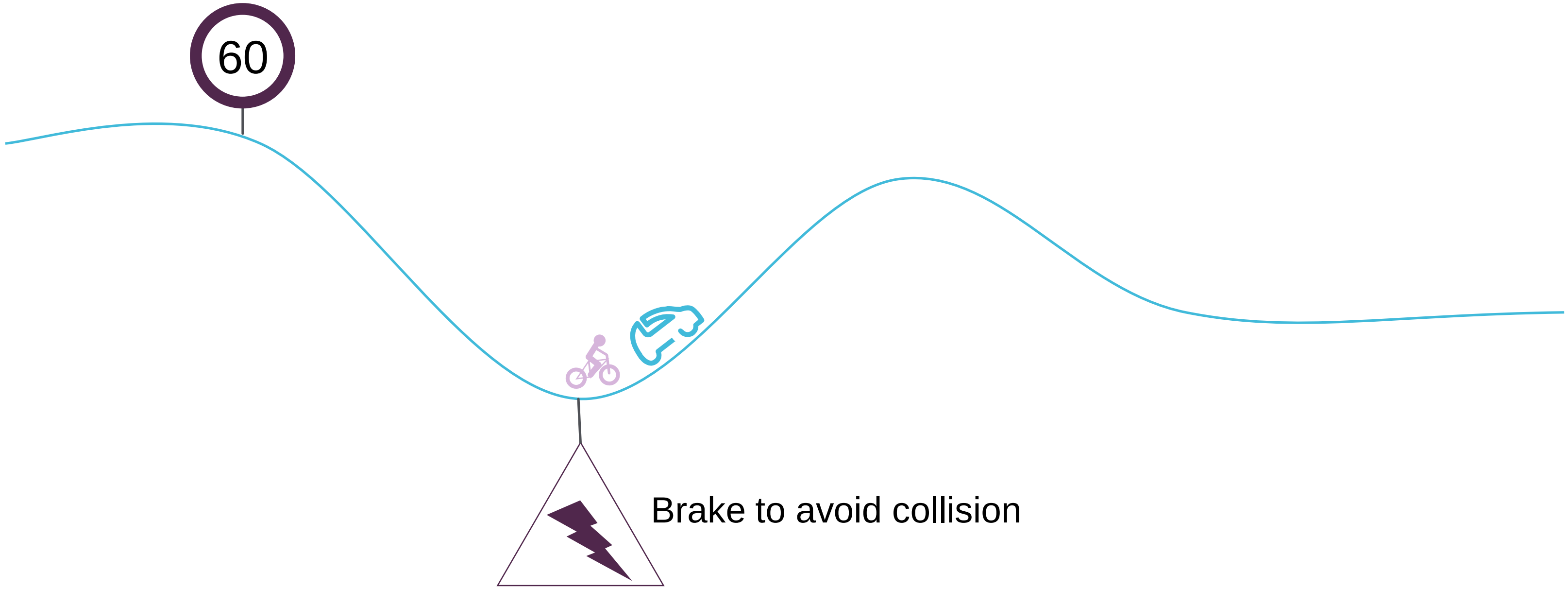
Assumptions
- Car drive at a constant speed.
- Cyclist is subject to gravity.
- Cyclist cannot overtake the car.
- Terrain between start and finish is known.

Constraints
- Cyclist want to maintain a safe distance with the car.
- Cyclist does not want to stop.
- Bicycle freewheels above a certain hub speed.

Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

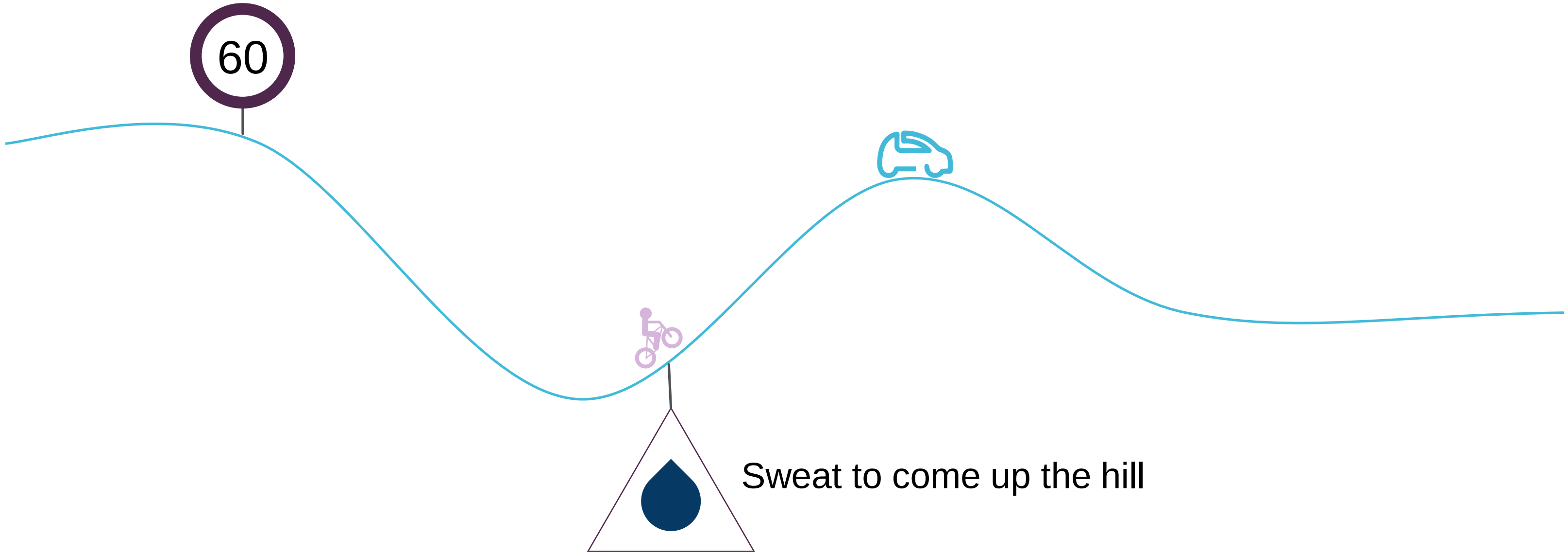
Classic control



Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

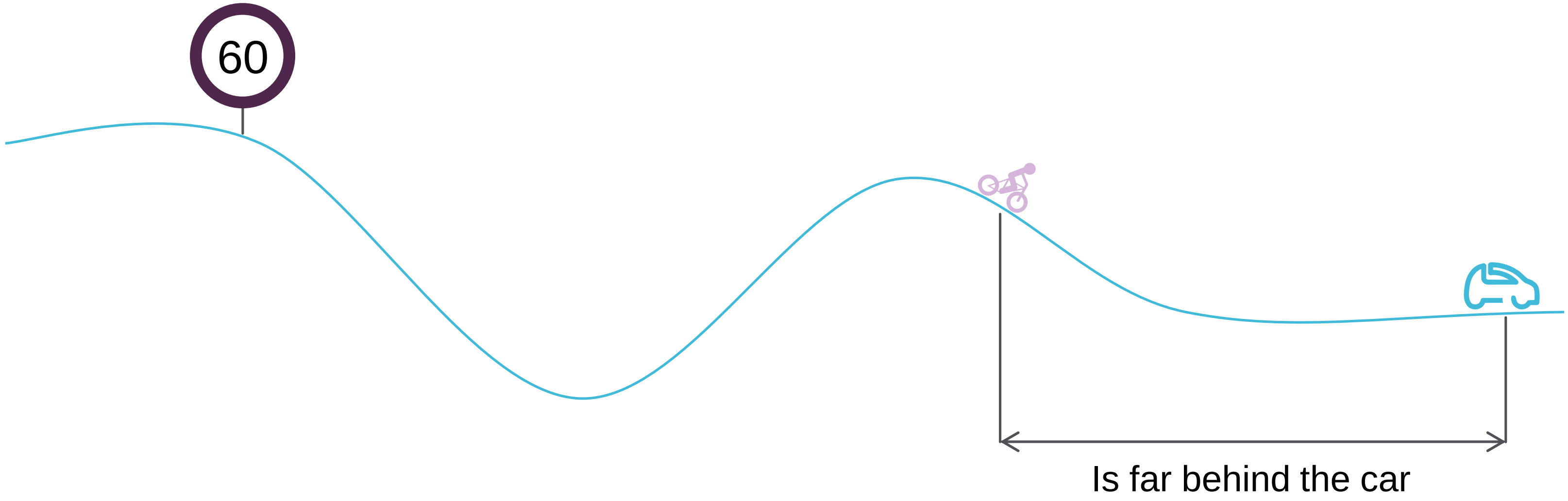
Classic control



Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

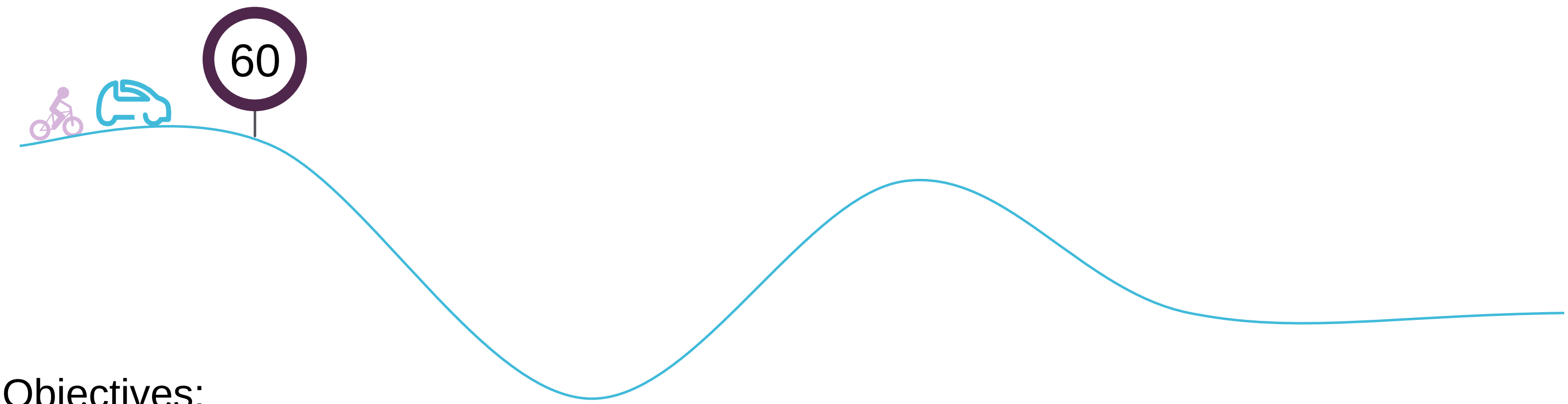
Classic control



Presenter: **Victor Dunand**

Source: Schneider Electric All Energy Conference 2018 presentation

What can be done differently?

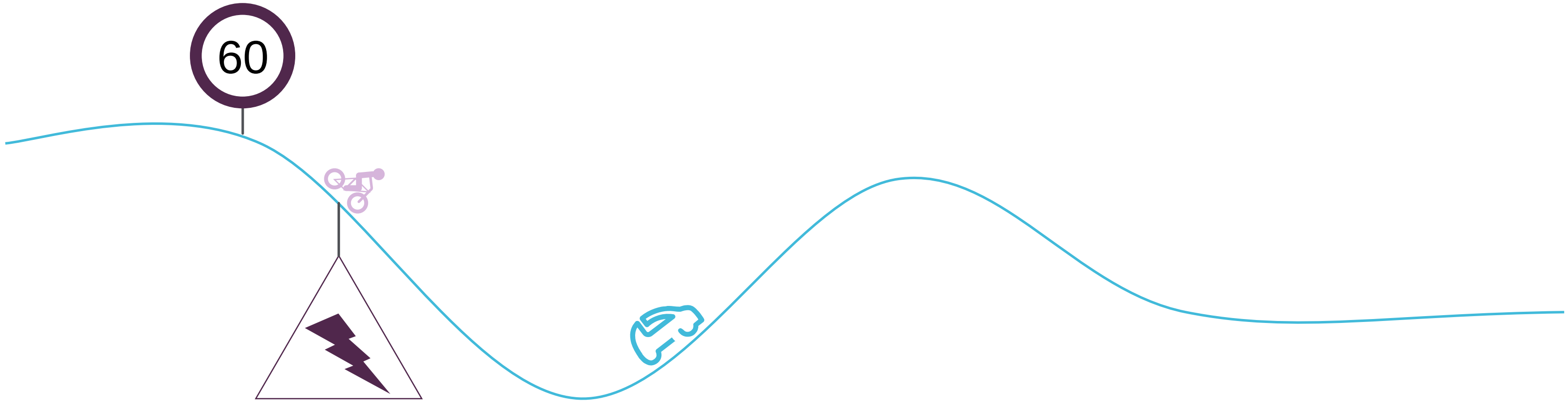


Objectives:
- Minimum amount of effort
- Reduce the travel time

Presenter: Victor Dunand

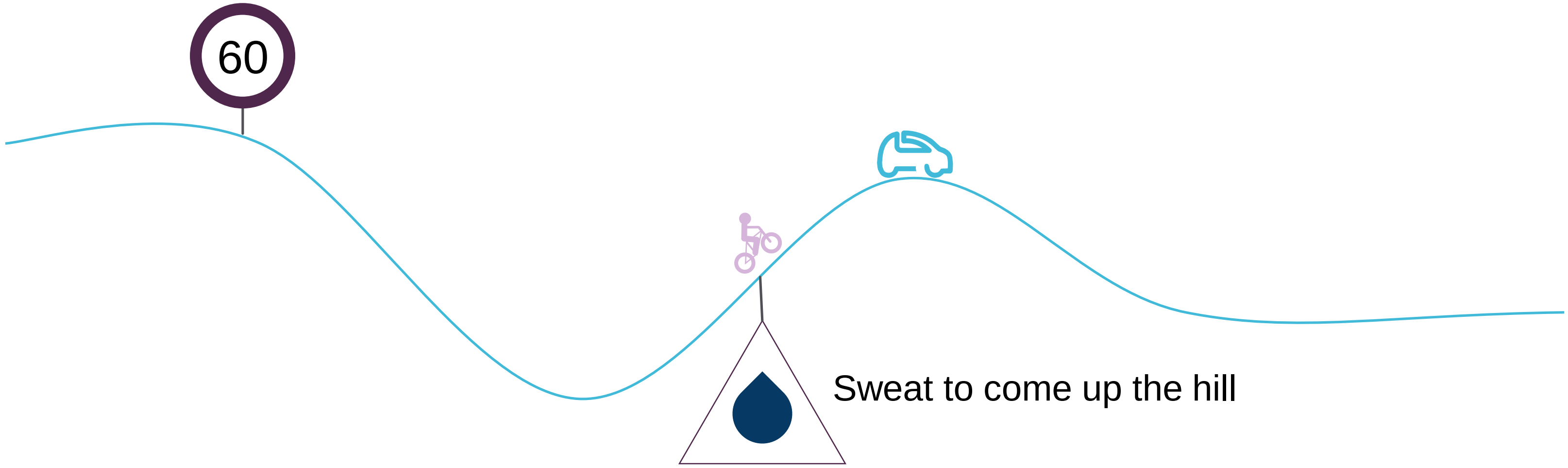
Source: Schneider Electric All Energy Conference 2018 presentation

Predictive control



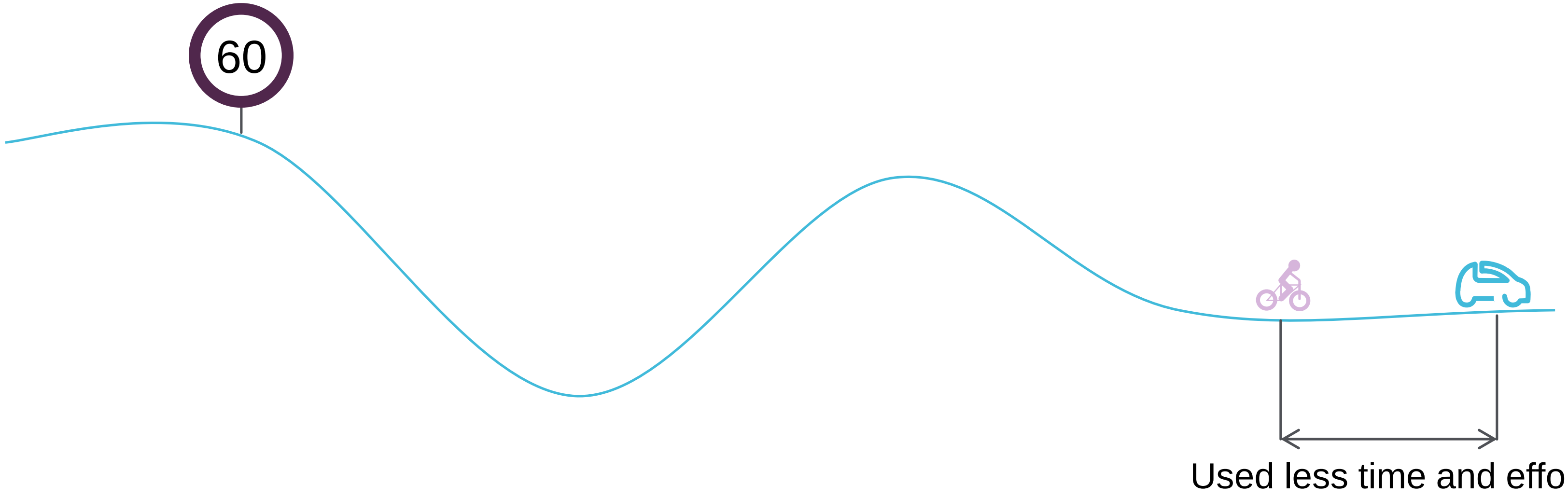
Brake to save
the potential energy

Predictive control



Presenter: Victor Dunand

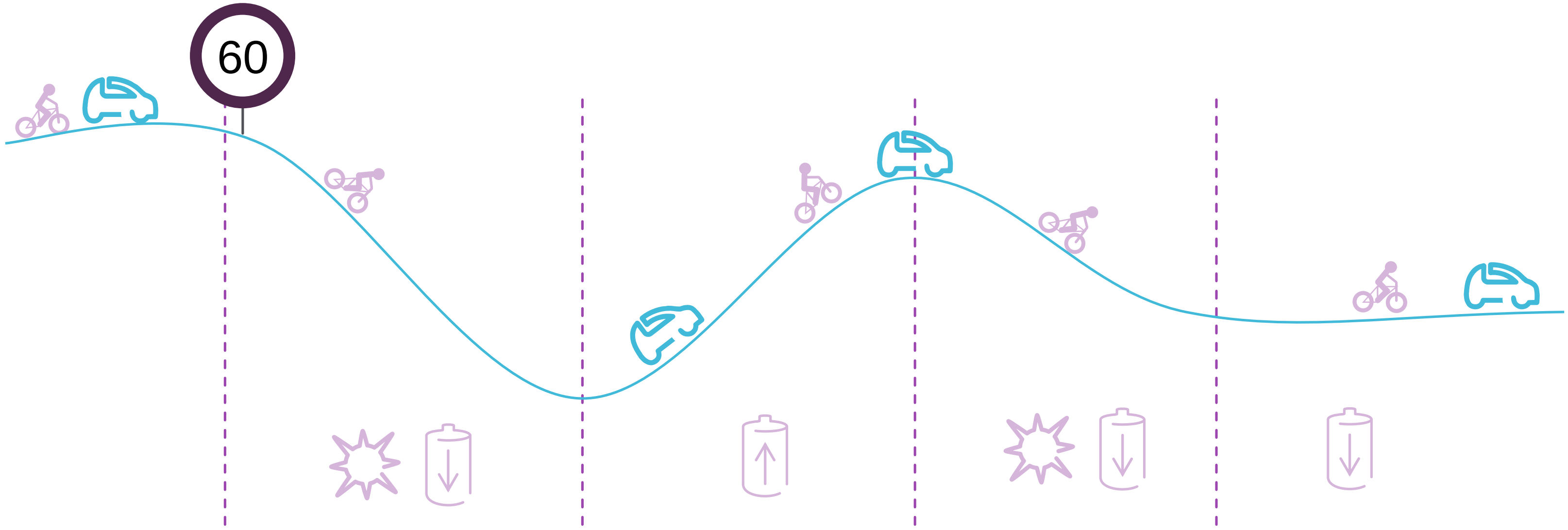
Predictive control



Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

Predictive control



Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

Solution

The Institution of Engineering and Technology

Model + Predictions + Objectives

Electricity cost x Generation forecast x Load forecast := Optimised control

Objectives can be:

- Reduce site demand
- Optimise energy usage to lower energy cost

Constraints

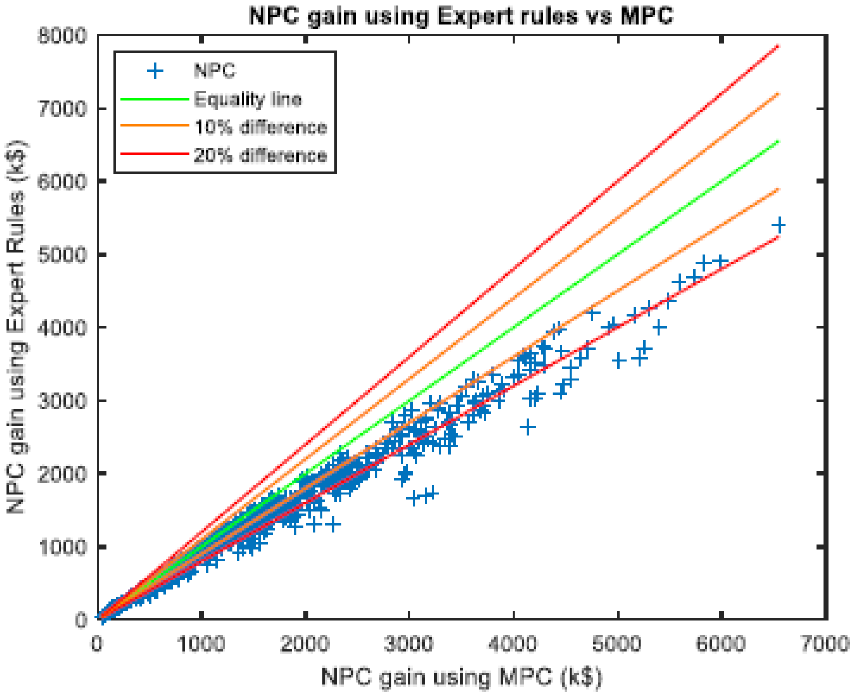
- Site operational constraint.
- Equipment operational constraint.

Presenter: Victor Dunand

Source: Schneider Electric All Energy Conference 2018 presentation

Benefit of MPC

- Anticipate future: forecasts
- Explicit handling of constraints
- Adapted for multi-variable control applications
- Adapts to changing context
- Increased value of ~10-20% over expert rules



Source: Schneider Electric NPC gain study (17,500 simulations)

Presenter: Victor Dunand

Case study

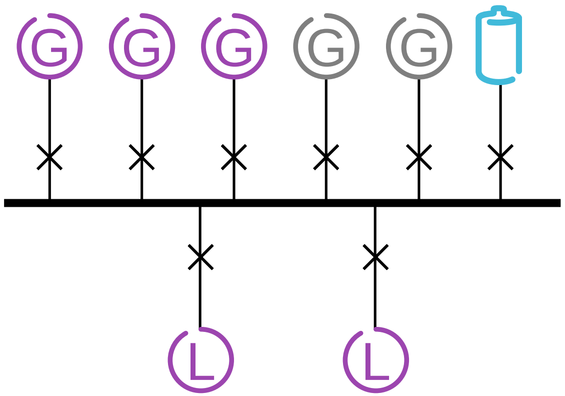
Presenter: Victor Dunand

Woodside Goodwyn A platform

Installation of a 1MWh Lion BESS to provide spinning reserve allowing to run with one less gas turbine

Benefits:

- Reduced fuel consumption
- Back-up power supply
- Reduced carbon emissions



Presenter: Victor Dunand

Santos Cooper bassin

Installation of solar PV + Battery Energy Storage System to power the beam pump replacing existing diesel generator.

Benefits:

- Reduced cost of operation
- 100% renewable power

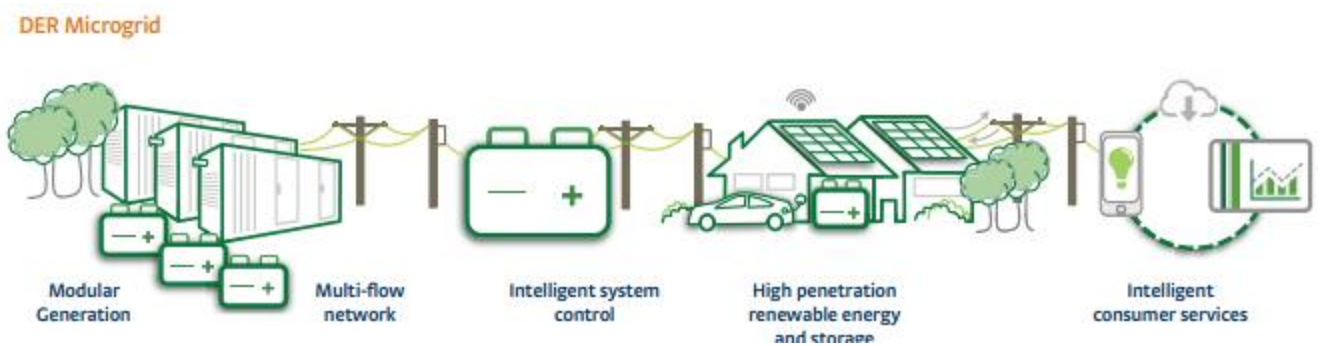
Presenter: Victor Dunand

Onslow Microgrid

Hybrid microgrid with gas turbine, solar PV and Battery Energy Storage System to supply the township of Onslow.

Benefits:

- Reduce carbon emission
- Lower electricity cost
- Increased supply reliability



Source: Horizon power

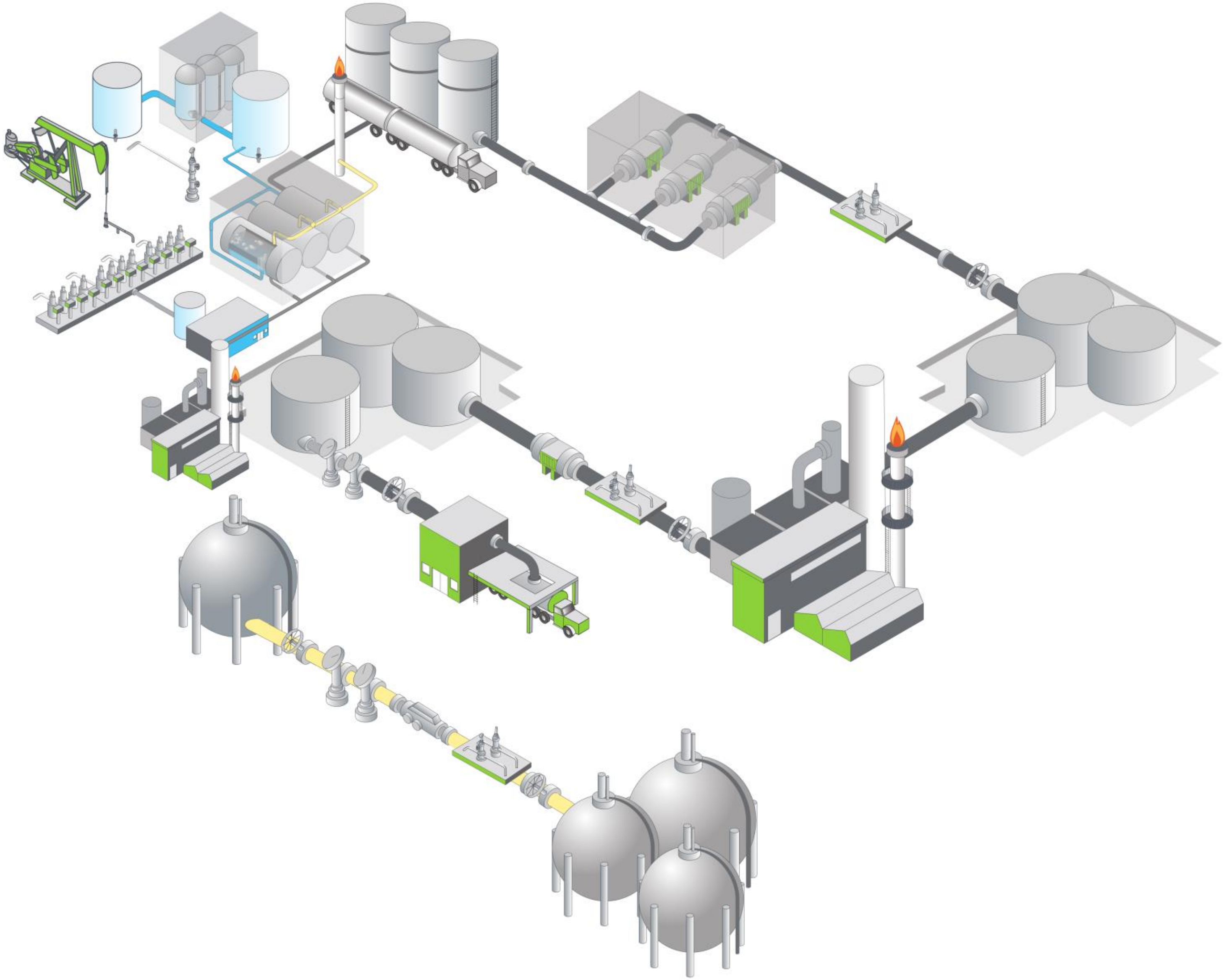
Presenter: Victor Dunand

Summary

3	Optimisation Control Protection and metering Electrical Infrastructure DER	3	3
Type of microgrids	Microgrid Architecture	Type of inverters	Case studies

Presenter: Victor Dunand

Where next?



Presenter: Victor Dunand