# Interconnection Specifications

*Presenter: NF van Schalkwyk*

*May 2024*

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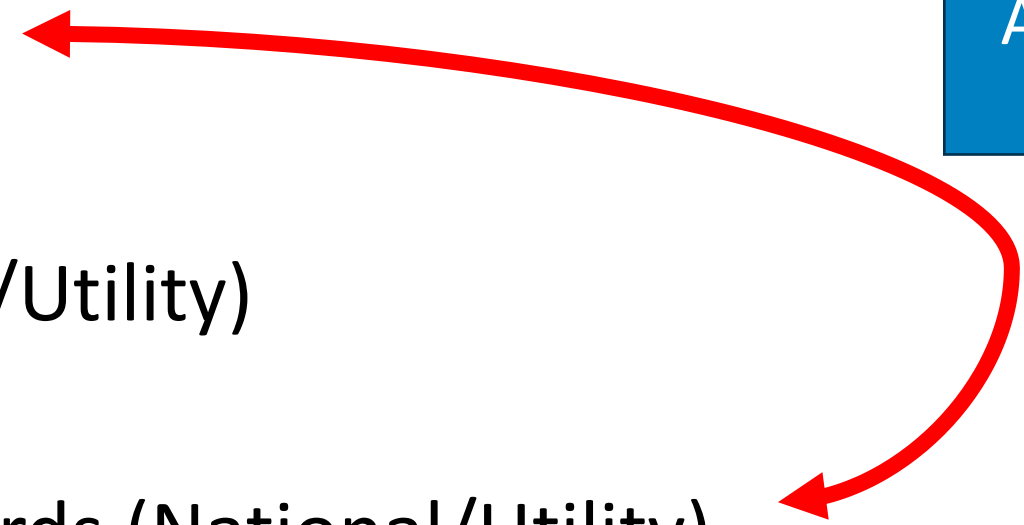
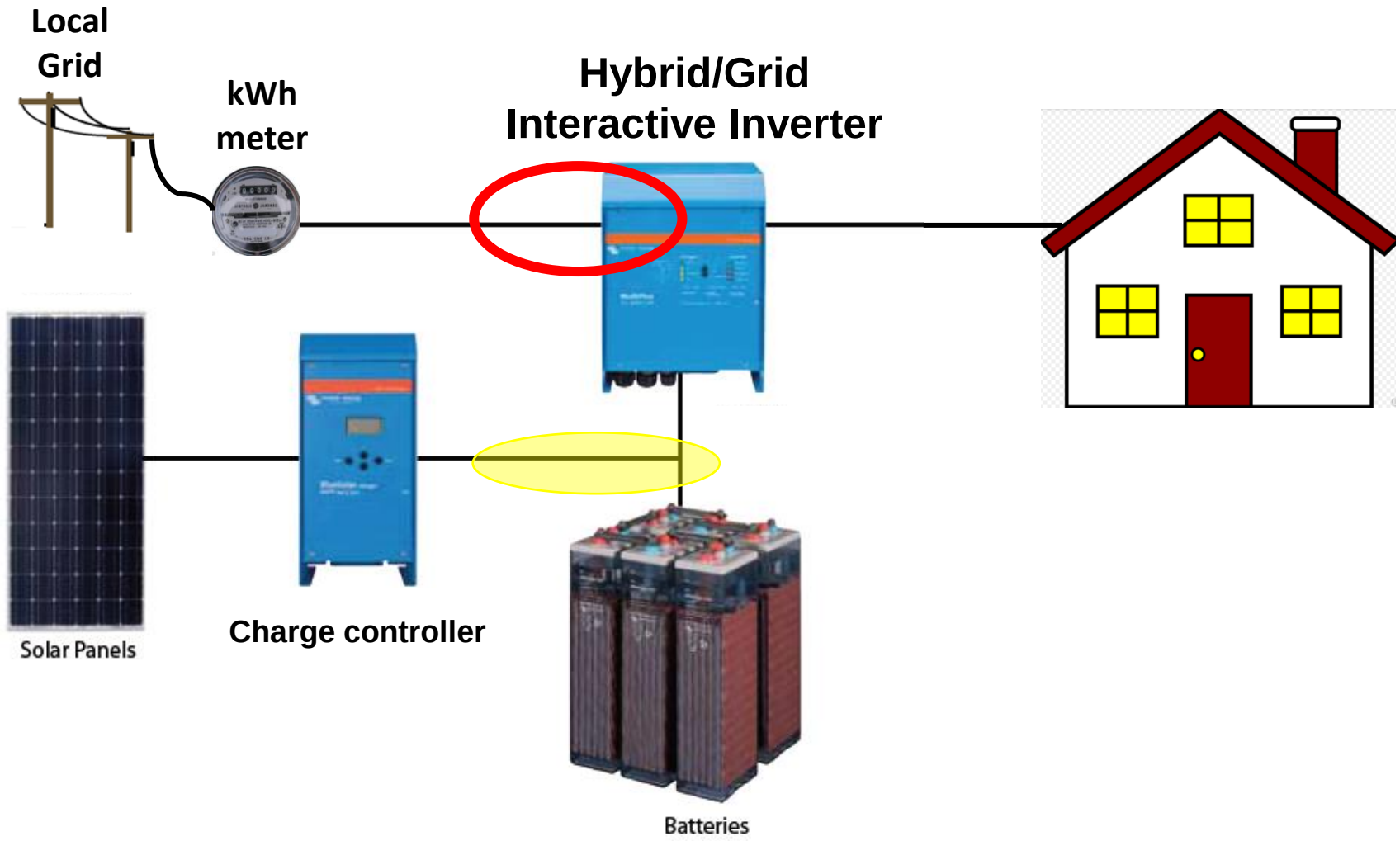
# Important Technical Documents

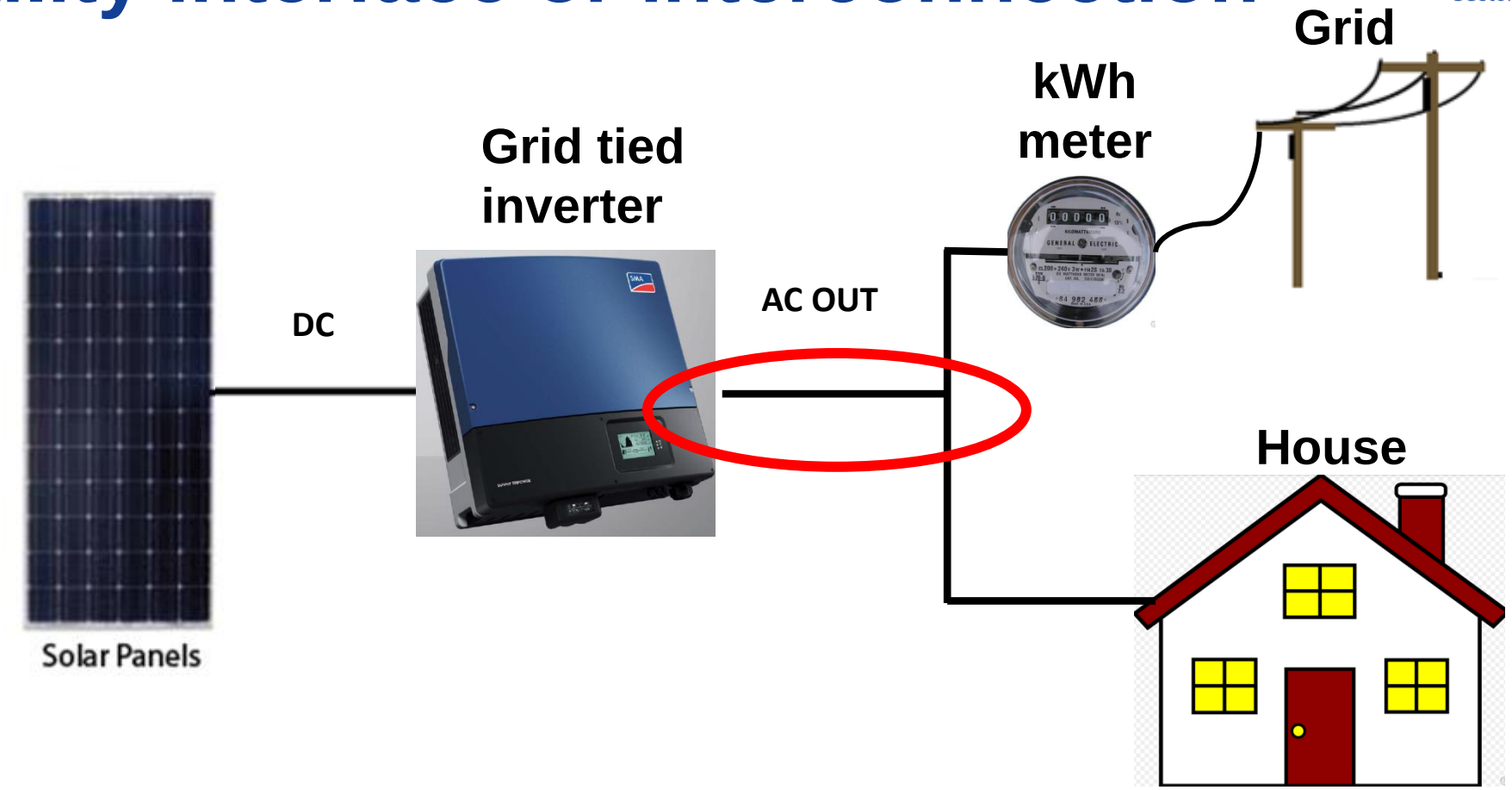
- Grid codes (National)
- Wiring codes (National/Utility)
- Interconnection standards (National/Utility)



# Utility interface or interconnection

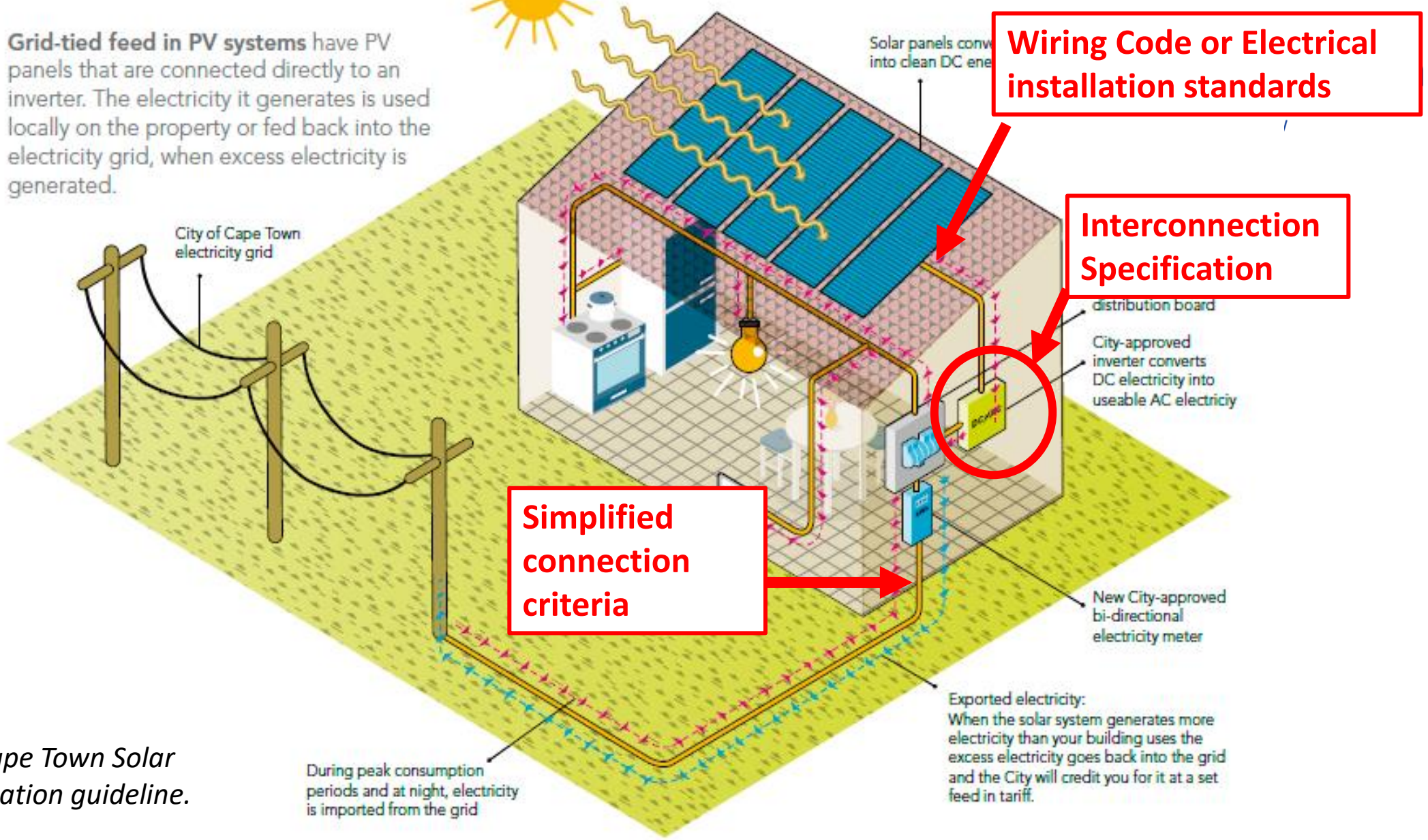


# Utility interface or interconnection



# 01 GRID-TIED FEED IN PV SYSTEMS

**Grid-tied feed in PV systems** have PV panels that are connected directly to an inverter. The electricity it generates is used locally on the property or fed back into the electricity grid, when excess electricity is generated.




**Wiring Code or Electrical installation standards**

**Interconnection Specification**

**Simplified connection criteria**

*Source:*
*City of Cape Town Solar PV installation guideline.*

# Grid Code(s)

- Level playing field for all participants
- “Rules of the road” for generators and consumers

- Generation Code
- Transmission Code
- Distribution Code

- IPP or DG Code(s)

Take care that requirements for DG, IPPs and Generation align

SUSTAINABLE ENERGY AFRICA

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Transforming Energy Sectors Globally

## INTERCONNECTION SPECIFICATIONS SESSION

# Wiring Code (Electrical Installation Standards)

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- General Electrical requirements
  - Wire- or cableways
  - Distribution boards
  - Labelling

# Wiring Code (Electrical Installation Standards)

- Solar PV specific requirements
  - Equipment standards
  - Earthing and Bonding
  - Protection (Overvoltage, Overcurrent, Reverse current, etc.)
  - Isolation
  - Monitoring
  - Neutral Earth bonding/bridge
  - Location of installation (To be included)

INTERCONNECTION SPECIFICATIONS SESSION

# Interconnection Specifications or Standards

# Interconnection specifications: Key aspects to cover

- Interface requirements
  - Requirements for the Utility
  - Requirements for the Generator (devices and units)

- Safety
  - Utility
  - Device / generator
  - Installation

- Metering

# Examples of interconnection standards

1) **IEEE 1547** – American interconnection requirements for **paralleling distributed** generation (DG) installations with electric power systems.

2) **IEC 61727** International standard requirements **for grid connected photovoltaic** (PV) power systems

3) **EN 50549-series** European Standard specifies requirements for **inverters for grid connected photovoltaic (**PV) systems.

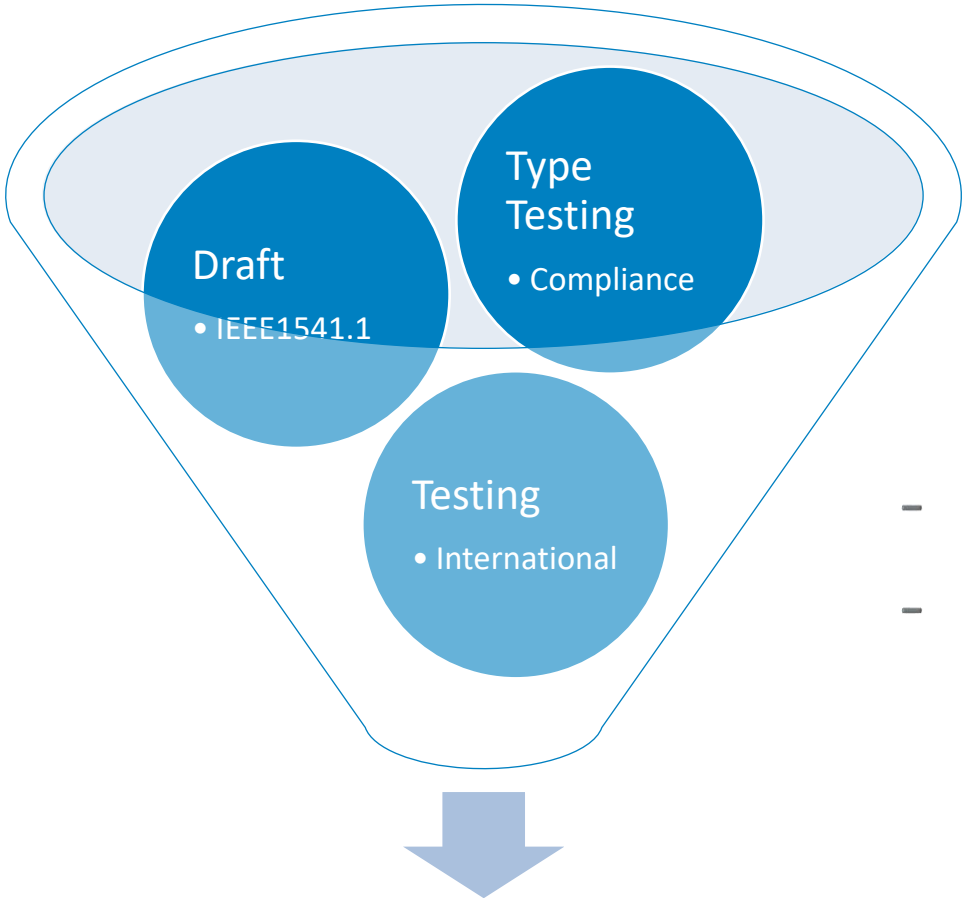
# Examples of interconnection standards

4) **VDE 4105** German national standard with requirements for **electronic equipment in low-voltage installations, including inverters for grid connected photovoltaic (PV) systems**

5) **NRS 097-2-series** South African industry specification specifying **utility interface requirements for embedded generation** on the **LV distribution network**.

6) **UK ER G98 / G99** UK specify requirements for **the connection of microgeneration and embedded generation (including solar PV)** to the **distribution network.**

# Type-testing




Compliant device

## Interface requirements

- No testing facilities in SA/Africa
- Rely on international accredited test houses

# Compliant Inverters: Approved Inverter list

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

**ENERGY DIRECTORATE**

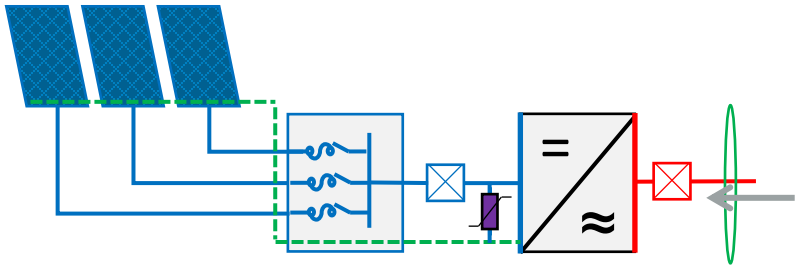
**TYPE TESTED INVERTERS/EQUIPMENT IN TERMS OF NRS 097-2-1**

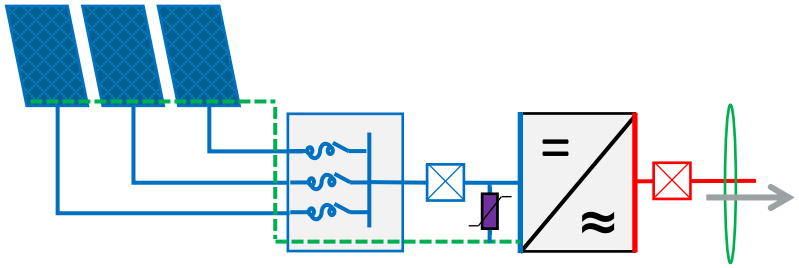
**7 February 2024**

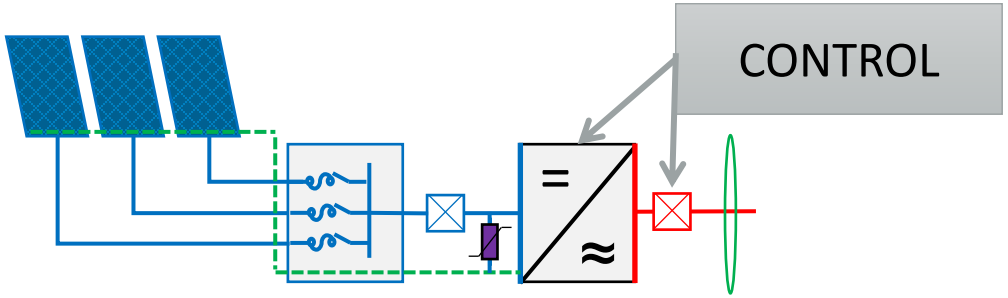
| Make | Model | Inverter / Equipment type | Test House | Certificate date | Certificate valid until | Report number | Certificate Compliance number | NRS 097-2-1: 2017 Ed2 Certification | NRS 097-2-1: 2017 Ed 2.1 Certification | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| ABB | TRIO-TM-50.0-400 | Grid-tied PV inverter | TUV Rheinland | 2019/07/15 | | 28110633 031 | AK 60141064 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | PVS - 50 - TL | Grid-tied PV inverter | TUV Rheinland | 2020/01/22 | | 28111830 029 | AK 60146346 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | PVS - 50 - TL - S | Grid-tied PV inverter | TUV Rheinland | 2020/01/22 | | 28111830 029 | AK 60146346 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | PVS - 50 - TL - SX | Grid-tied PV inverter | TUV Rheinland | 2020/01/22 | | 28111830 029 | AK 60146346 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | PVS - 50 - TL - SX2 | Grid-tied PV inverter | TUV Rheinland | 2020/01/22 | | 28111830 029 | AK 60146346 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | PVS-100-TL | Grid-tied PV inverter | TUV Rheinland | 2019/11/29 | | 28110923 035 | AK 60144898 0001 | Yes | | Inverter may only be used in plants according to Category A3: 100 kVA - 1MVA and connection to the grid via an external customer MV/LV AC transformer. |
| ABB | REACT2-UNO-3.6-TL | Grid-tied PV inverter | TUV Rheinland | 2018/11/07 | | 28111587 003 | AK 60134062 0001 | Yes | | A maximum of three REACT2 -BATT may be used in combination with this inverter unit |
| ABB | REACT2-UNO-5.0-TL | Grid-tied PV inverter | TUV Rheinland | 2018/11/07 | | 28111587 003 | AK 60134062 0001 | Yes | | A maximum of three REACT2 -BATT may be used in combination with this inverter unit |
| ABB | CM-UFD.M31M | Network & system relay | TÜV SÜD | 2022/10/28 | | 713200958-000 | ESY 0442540043 Rev.00 | No | No | Network and system grid protection voltage and frequency relay only in accordance with VDE-AR-N 4105:2018. Must be programmed ito NRS 097-2-1 or the applicable South African Grid Codes and may only be used in conjunction with approved NRS 097-2-1 type tested inverters on this list. |
| ABB | CM-UFD.M31 | Network & system relay | TÜV SÜD | 2022/10/28 | | 713200958-000 | ESY 0442540043 Rev.00 | No | No | Network and system grid protection voltage and frequency relay only in accordance with VDE-AR-N 4105:2018. Must be programmed ito NRS 097-2-1 or the applicable South African Grid Codes and may only be used in conjunction with approved NRS 097-2-1 type tested inverters on this list. |
| Afore | HNS3000HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS3600HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS4000HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS4600HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS5000HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS5500HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS6000HS | Hybrid PV inverter grid-tied | Dekra | 2020/09/17 | | 6076139.50 | 6076139.01AOC | | Yes | |
| Afore | HNS3000HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS3600HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS4000HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS4600HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS5000HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS5500HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | HNS6000HS-HV | Hybrid PV inverter grid-tied | Dekra | 2020/09/18 | | 6076141.50 | 6076141.01AOC V1.1 | | Yes | |
| Afore | AF3K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |
| Afore | AF3.6K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |
| Afore | AF4K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |
| Afore | AF4.6K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |
| Afore | AF5K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |
| Afore | AF5.5K-SL | Hybrid PV inverter grid-tied | Dekra | 2021/03/10 | | 6098057.50 | 6098057.01AOC | | Yes | |

*Source: City of Cape Town Approved inverter list*

# Utility Compatibility







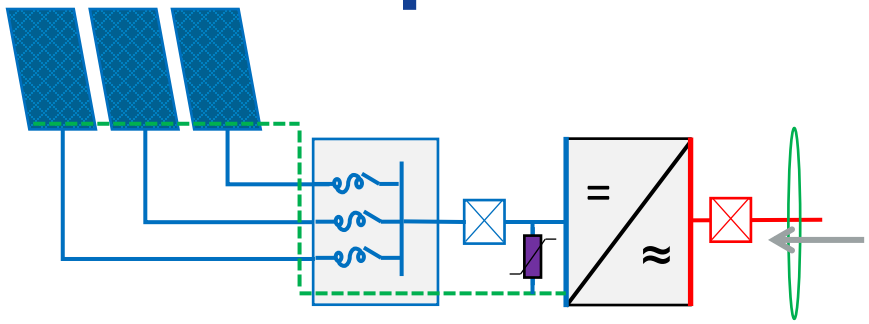

Summarise as:

1) What to expect?

2) What is allowed?

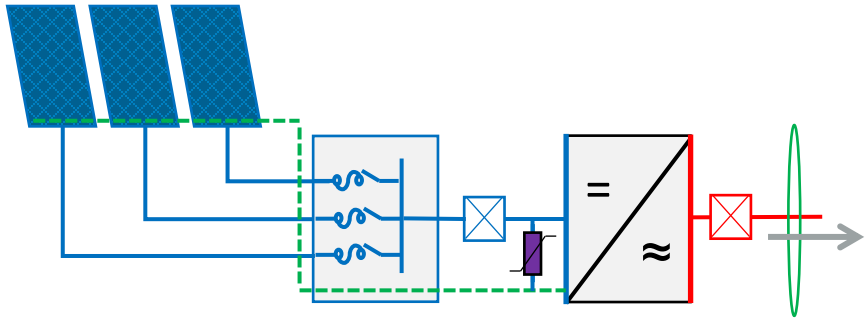
3) What to do?

# What to Expect?



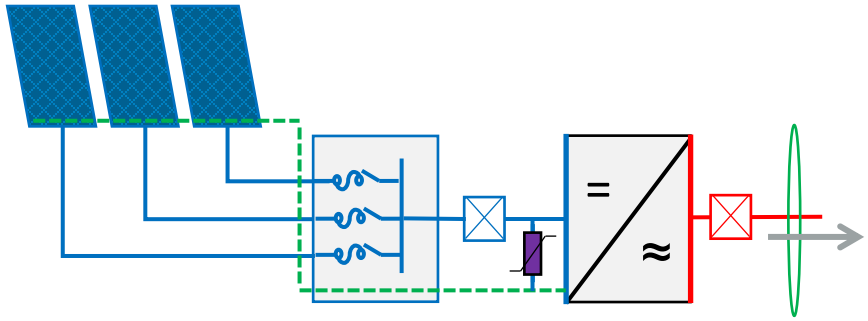

- Voltage, current and frequency
- EMC
- Power Quality
- Fault level

# What Allowed?



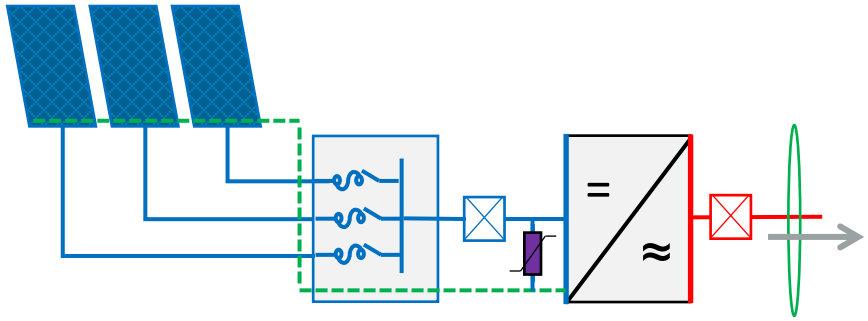

- Inject current - not voltage
  - Voltage control (future requirements) may lead to instability
- Synchronise
- Operate within trip limits
  - DC current and residual DC current
  - Voltage and frequency
- No islanding
  - Out of phase reclosing

# What Allowed?




- PQ contributions
  - Flicker
  - Voltage unbalance
  - Harmonics and waveform distortion
  - DC injection

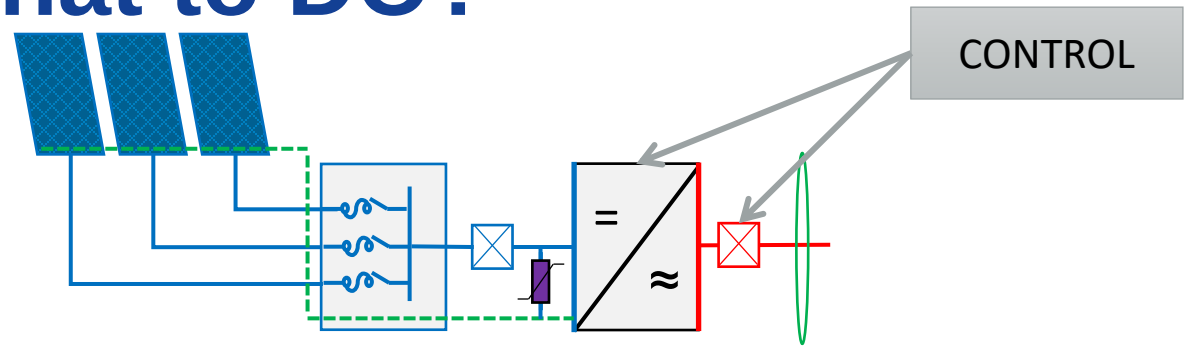
# What Allowed?




Applies at the generator terminals!

- Power factor
- Typical values (South Africa based on international):
  - Up to 100 kW pf > 0.98
  - Between 100 kW and 1 MW pf > 0.95
- EMC / Mains signalling

# What to DO?



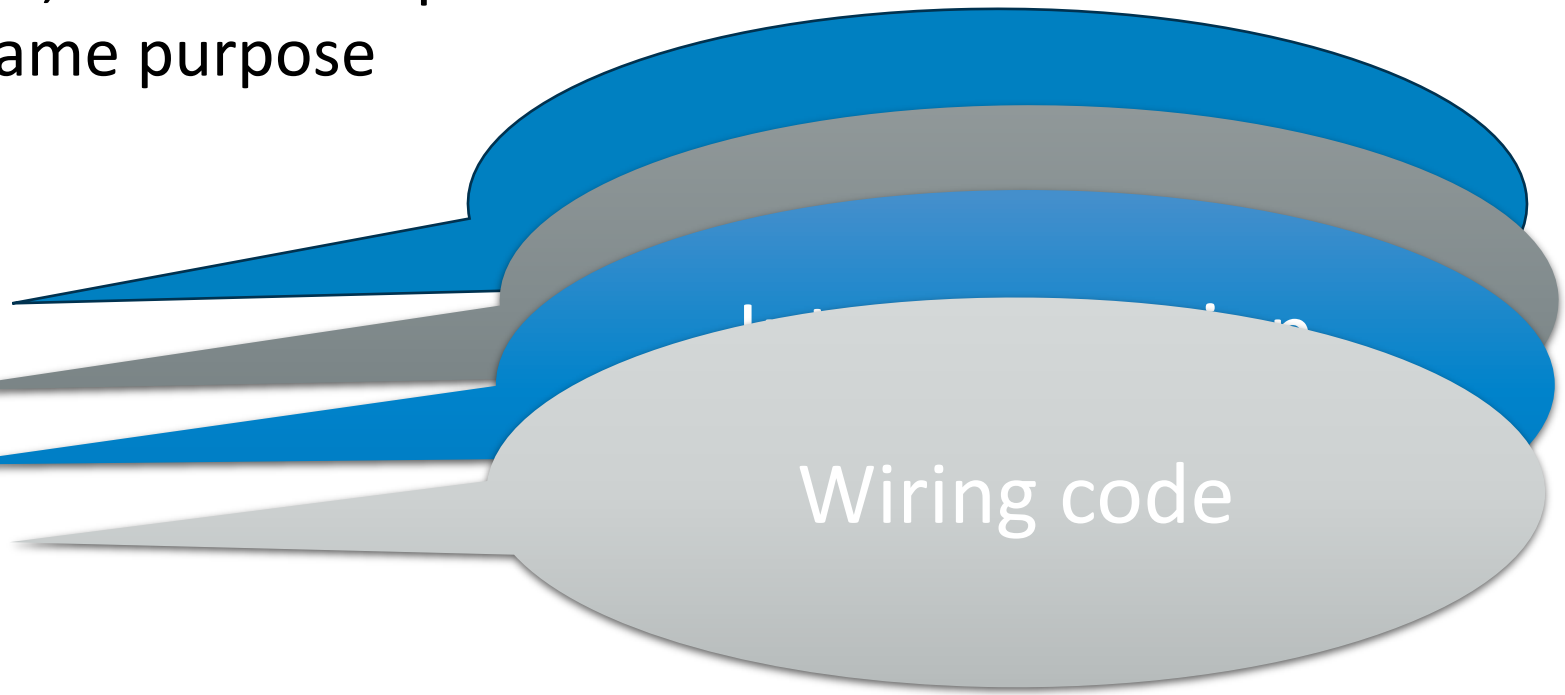

- **Safety disconnect unit**

- Ensure disconnection
  - Including Anti-islanding
- Redundancy

- Non-inverter – relays VDE 0126-1-1 certified

# TAKE HOME MESSAGES

- Several standards, codes and specifications
  - All have the same purpose




- Equipment
- Network
- Interface
- Installation

- Align and work together for a safe sustainable power system