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Extending the capacity of the Power Grid

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www.cir-strategy.com/events/cleanpower

The challenge

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- Renewable energy targets
- Utility's statutory responsibility
    - Preserve quality of supply
    - Minimize disruptive impact
- Connection constraints
    - Grid design limits
    - Costly upgrades
    - Unnecessarily replace network assets
- Renewable energy schemes: financial viability

Power Grid complexity

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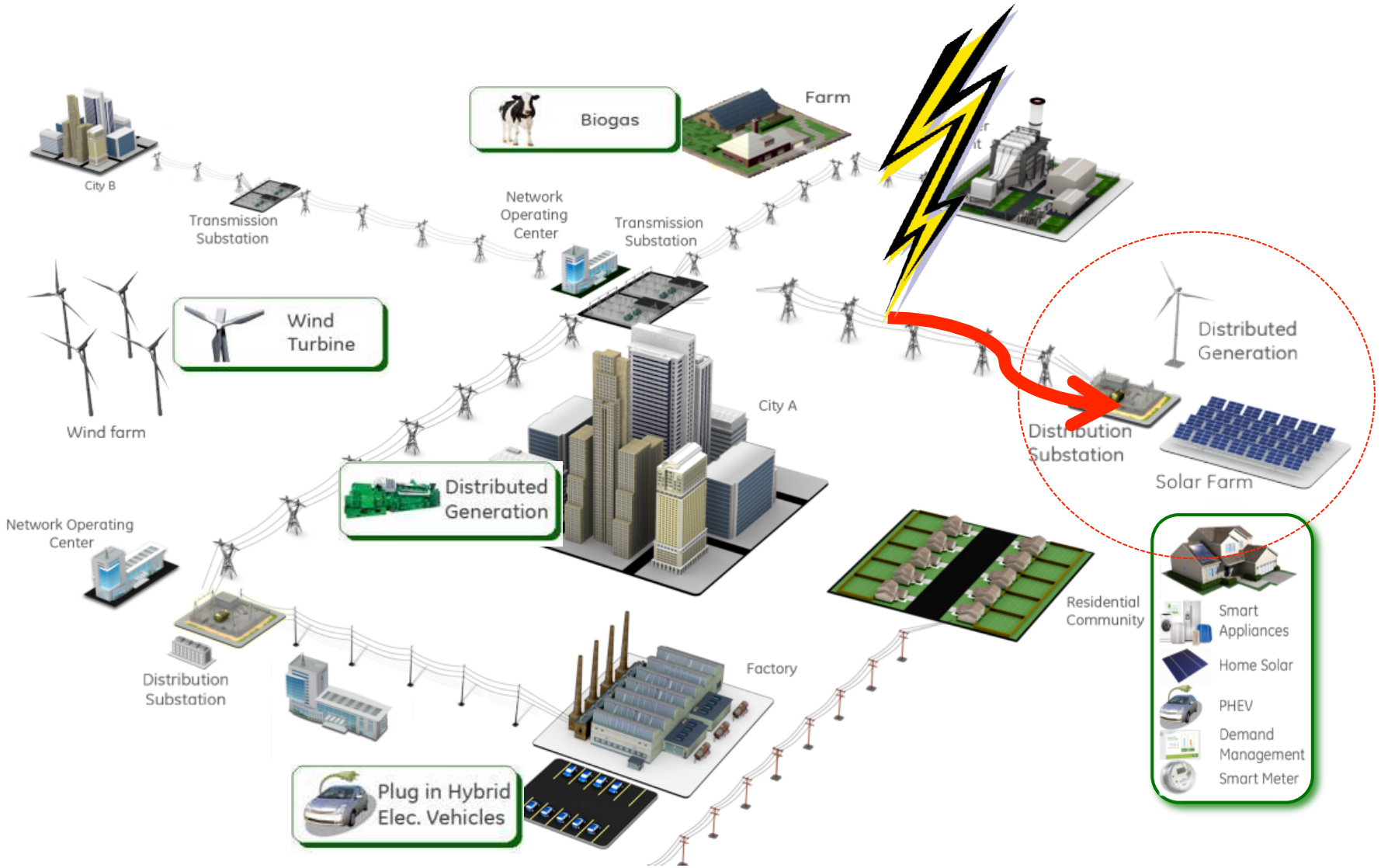

Generation dynamic

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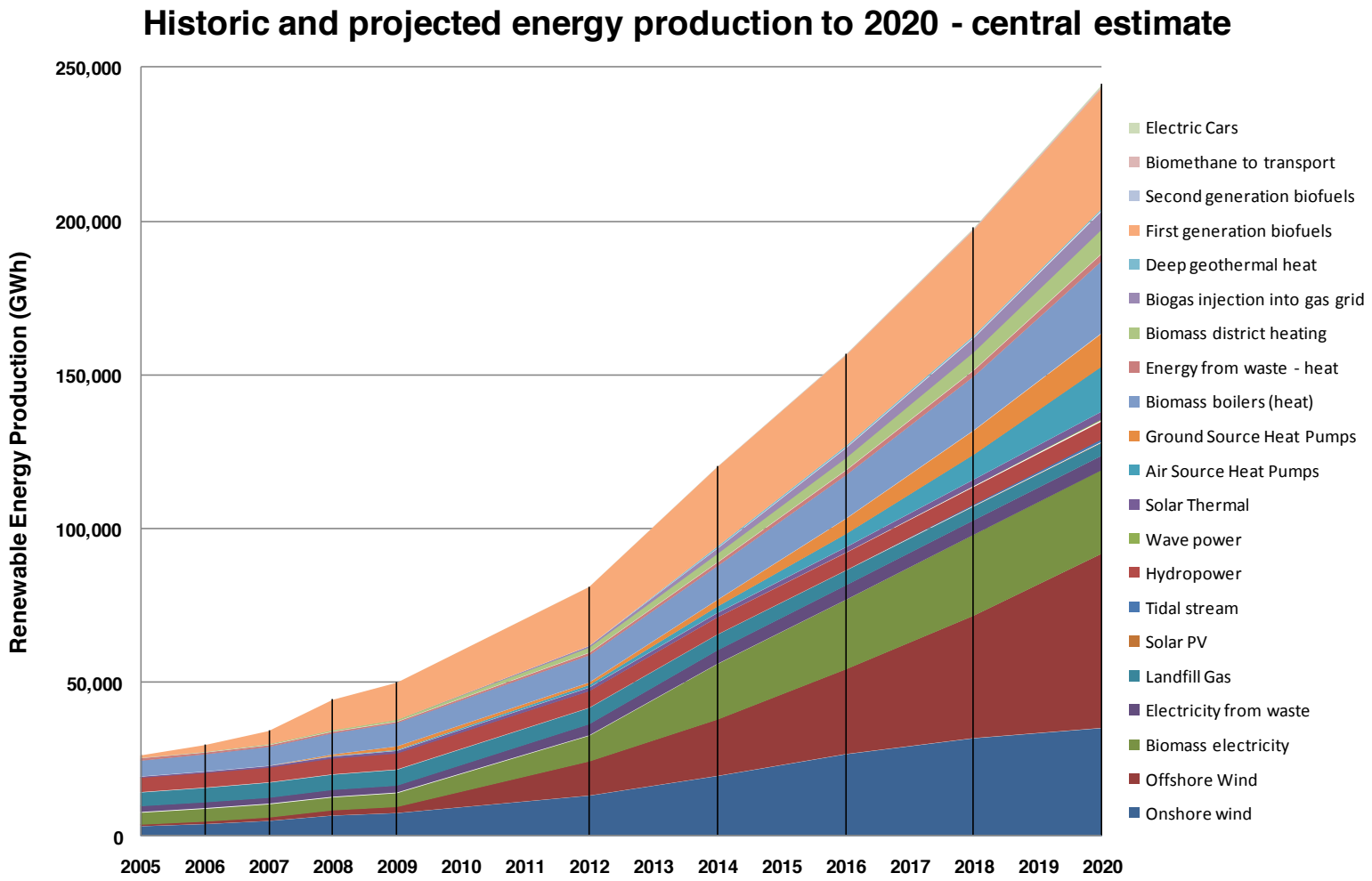


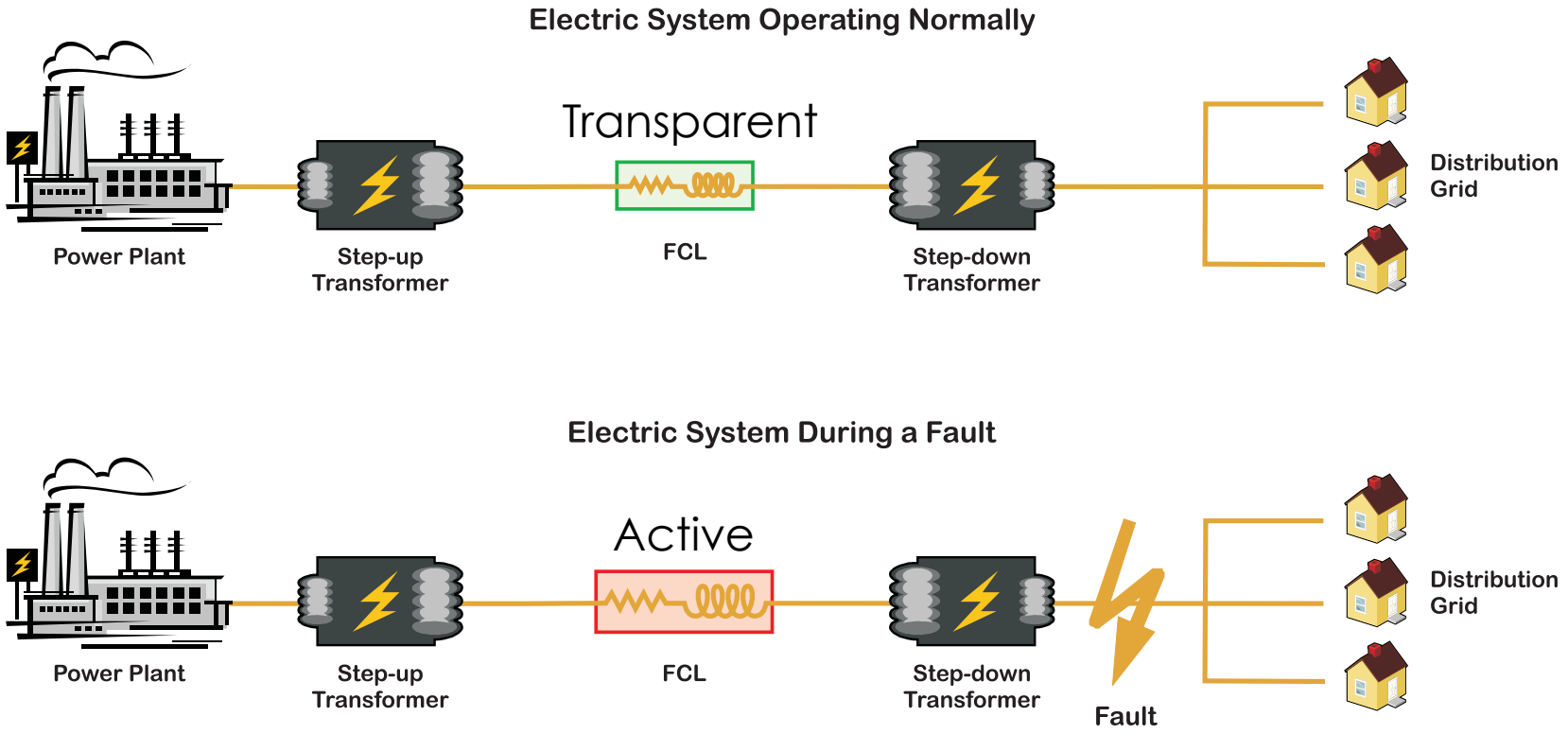
*Analysis of Renewables Growth to 2020: AEA Technology report to DECC

What is a fault?

A fault is any abnormal (unplanned for) flow of electric current

- Power systems are designed to accommodate a maximum fault current
- Circuit breakers and protection systems isolate faults, limiting loss of service and network equipment damage
- Addition of new power sources changes a power system's characteristics
  - increasing the maximum fault current, beyond the system design limits

Fault Current Limiter



A FCL limits the maximum level of a fault current when a fault occurs….allowing the existing power system protection equipment to safely isolate the fault

Fault event waveform

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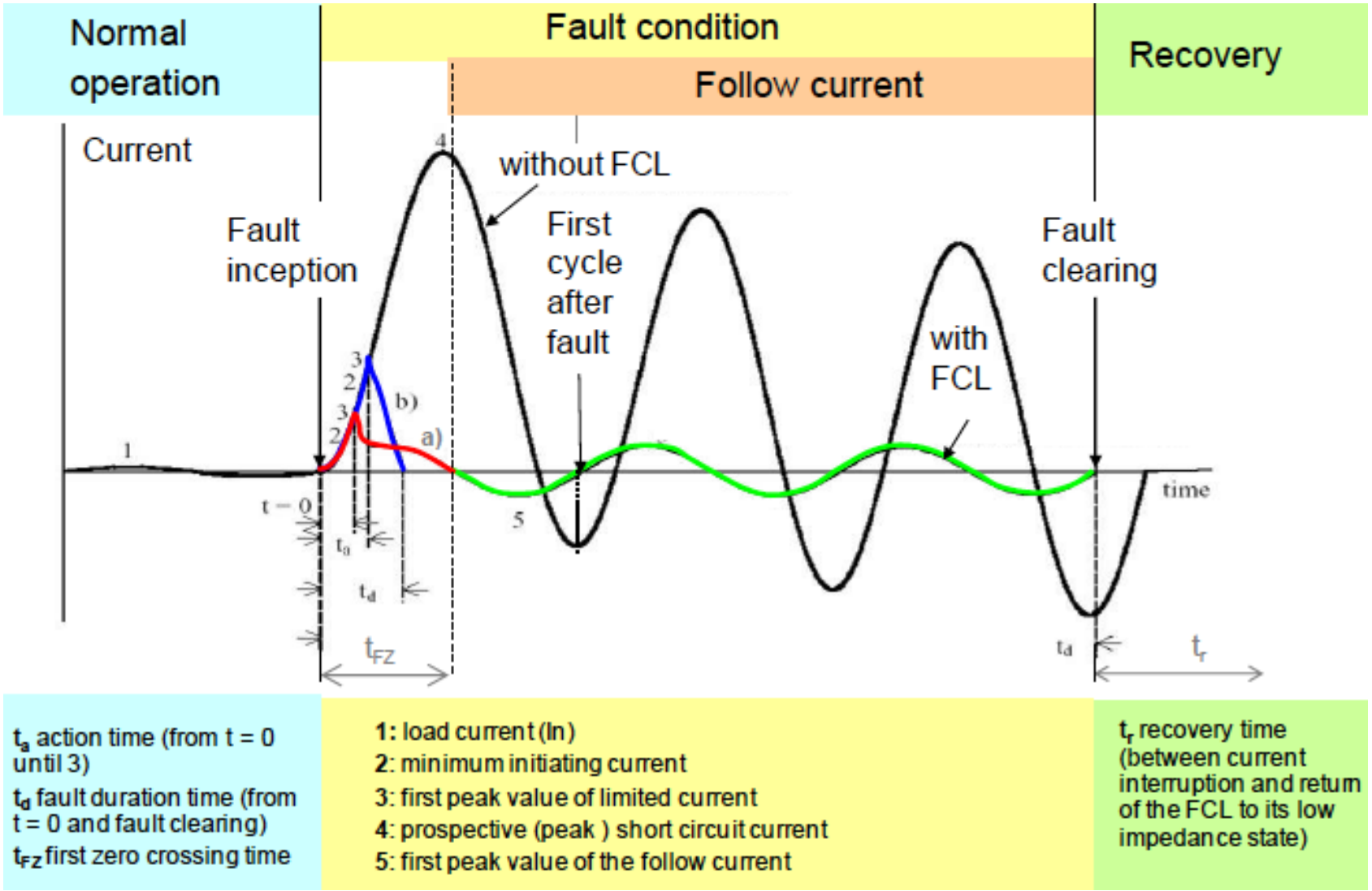

t_a action time (from t = 0 until 3)

t_d fault duration time (from t = 0 and fault clearing)

t_{FZ} first zero crossing time

1: load current (In)
2: minimum initiating current
3: first peak value of limited current
4: prospective (peak) short circuit current
5: first peak value of the follow current

t_r recovery time (between current interruption and return of the FCL to its low impedance state)

Fault limiting methods

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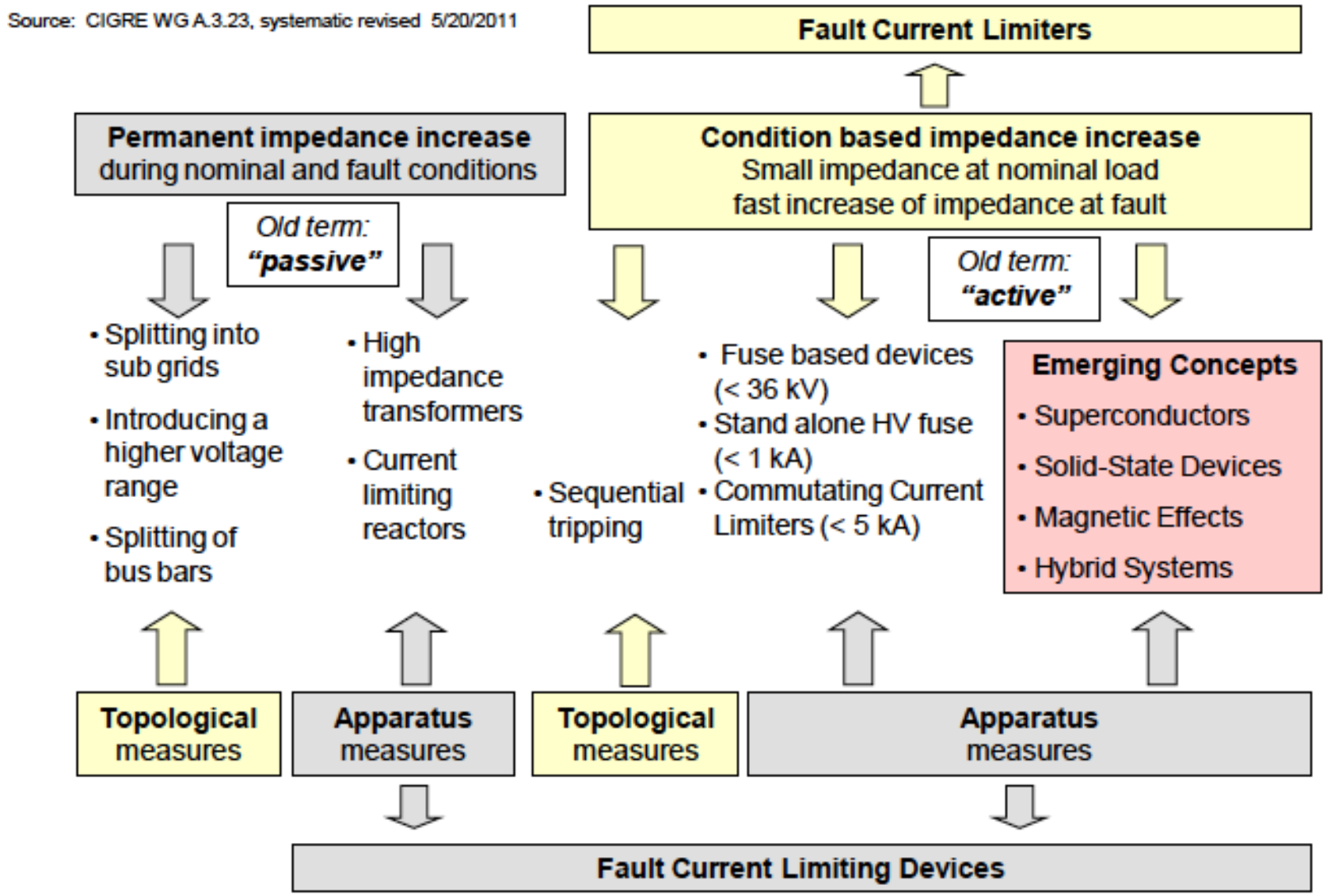

FCL technologies

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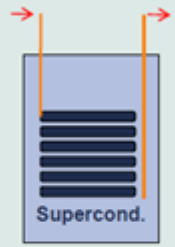
Superconductors

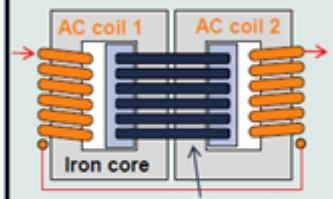
Resistive SCFCL



- ☺ Compact, lightweight
- ☺ Simple design
- ☹ Current leads to 77 K

DC biased iron-core SCFCL

(„saturated" iron core)

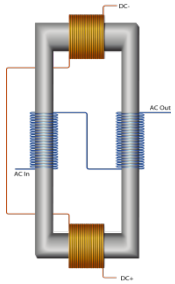


Characteristics

- ☺ Fast recovery
- ☺ Superconductor at DC
- ☹ Weight
- ☹ Non-metallic cryostat

DC Magnet

DC bias Ferromagnetic



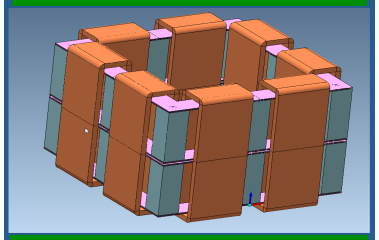
DC bias keeps core in saturation

Variable impedance

Heating losses

FC Limited

Current dependent inductor



No Cryostat

Low heating losses

Passive system

Cryogenic = Operational Cost

Power supplies = Operational Cost

Electronic control = Operational Cost

Passive Autonomous System

No Overheads

Applications & benefits

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- Power generation feeders: Enabling renewable energy connection
- Defer capital expenditure: Extending useful life of existing network assets
- Network 'Meshing": Improving network reliability
- Bus coupling: Increasing operational flexibility
- Employing lower rated equipment: Reducing network impedance
- Reducing voltage sags: Improve power quality

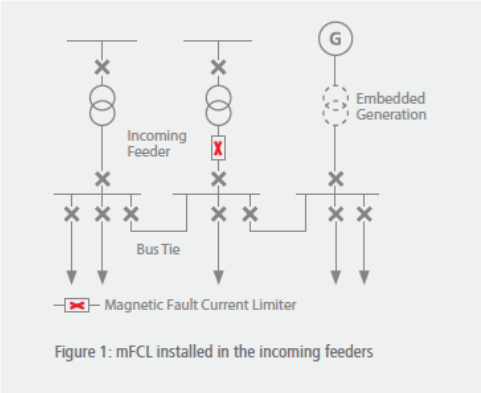

Figure 1: mFCL installed in the incoming feeders

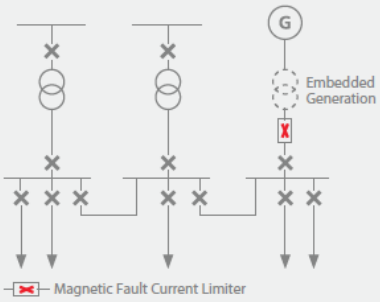

Figure 2: mFCL installed in the distributed generator tie

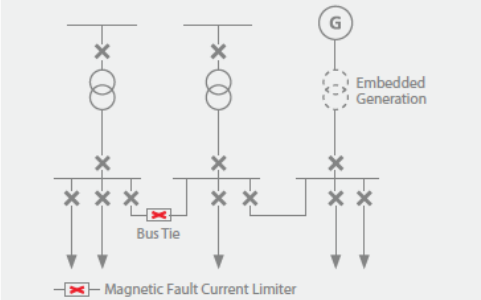

Figure 3: mFCL installed in the bus tie

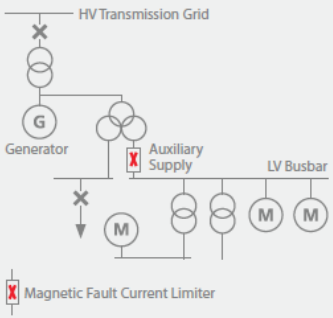

Figure 4: mFCL installed in the power station auxiliary supply

Market potential

- FCLs identified as 'technology most likely to realise significant value from public sector innovation support'*
- UK Deployment estimates*
  - 296 – 406 units by 2020
  - 1182 – 1625 units by 2050
- More than 21 SCFCL trials across the globe
  - UK, Germany, China, Japan, Korea, Spain, USA…..

*Reference: Technology Innovation Needs Assessment: August 2012

Deployment benefits

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- FLEXGRID (WPD Tier 2 LCNF project) advanced fault level management in Birmingham
  - Cost to upgrade: £48.4m
  - Cost to add FCLs: £10m
  - Potential saving: £38.4m

- FCLs are estimated to have an impact of between £0.8bn - £1.1bn value in business creation, together with £200m value in meeting emissions targets

*Reference: WPD Flexgrid project: LCNF submission
TINA report August 2012

Fit & Forget

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'Ideal' Fault Current Limiter characteristics

- ✓ Lower Capital Costs: compared with replacing network assets
- ✓ Quick to install: single phase foot-print
- ✓ Performance criteria met (reliability & longevity)
- ✓ Negligible operations & maintenance costs
- ✓ No unusual health & safety issues
- ✓ Fail-safe

Next generation FCL

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- Spin-off from Cardiff University (Wolfson Centre for Magnetics):novel concept meets all ‘ideal’ criteria
- Backed by Fusion IP & IP Group
- DECC grant award to build demonstrator
- UK based manufacturing partners

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Extending the capacity of the Power Grid

Part of the fusion IP portfolio

References

- WPD FLEXGRID project: LCNF Tier 2 submission
- Technology Innovation Needs Assessment (TINA): August 2012
- Analysis of Renewables Growth to 2020: AEA Technology
- Application and Feasibility of Fault Current Limiters in Power Systems: CIGRE WG A3.23 – June 2012

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Part of the fusion IP portfolio