Networks & Markets Opportunities & challenges

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Network Codes and System Design Strategy

NEA Workshop on advanced reactors
and future energy markets
Paris 12 April 2017

Agenda

1. Future Energy Scenarios
   - Low carbon - Increased RES (even dominance?) - Many small distributed sources
2. Network challenges
   - Wider energy sharing- network capacity? Greater variability– adequacy & flexibility?
3. New nuclear adding to network / market challenges
4. New nuclear opportunities to deliver solutions for networks / markets
5. Summary of desirable characteristics

1 Future Energy Scenarios – Production mix – MAF + TYNDP 2016

Low carbon - Increased RES (even dominance?) - Many small distributed variable power sources

2020 and 2025 from 2016 report on Mid-term Adequacy Forecast

RES part including large hydro

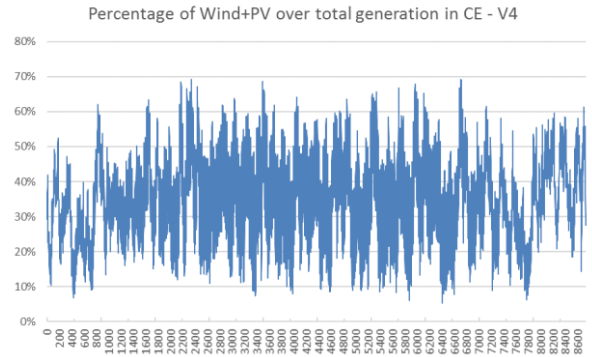
Figure 14 - Comparison Generation Mix: RES (green) vs Conventional (purple) - 2020 (left) - 2025 (right)

Vision 4 for 2030 focus on just wind & PV

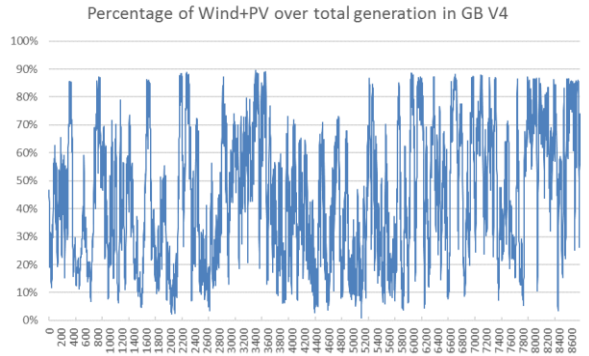
Hourly production

% Wind + PV

Continental Europe



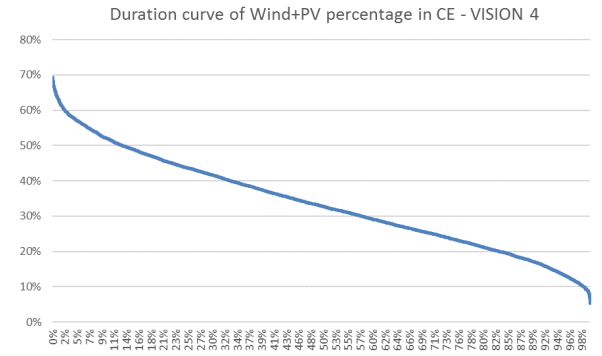
Great Britain



Duration curve

% Wind + PV

Continental Europe



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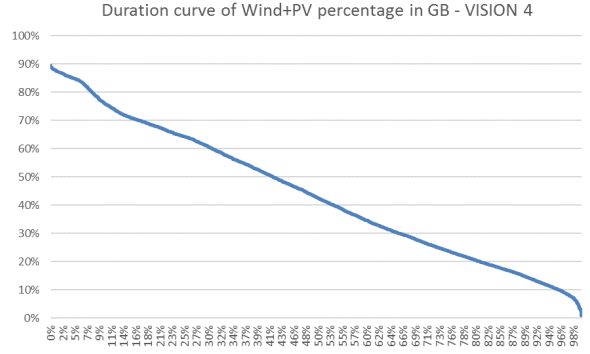


2 Network challenges

Wider energy sharing- network capacity? Greater variability– adequacy & flexibility?

- **Significant expansion of network capacity needed**
  - Main focus on sharing RES, but also applies to connecting new nuclear
  - Public acceptance a major challenge for TSOs
  - Also: Push networks harder / build under ground / in sea – use more HVDC
- **Greater variability of RES –focus on best resource**
  - Adequacy a challenge, when fossil fuel plant withdrawn to go low carbon
  - In operation fast increases & reductions in RES, at least locally
  - Pressure on other capacity to be VERY FLEXIBLE
    - Frequent and deep part loading
    - Delivery of reserves – some fast

3 New nuclear adding to network / market challenges

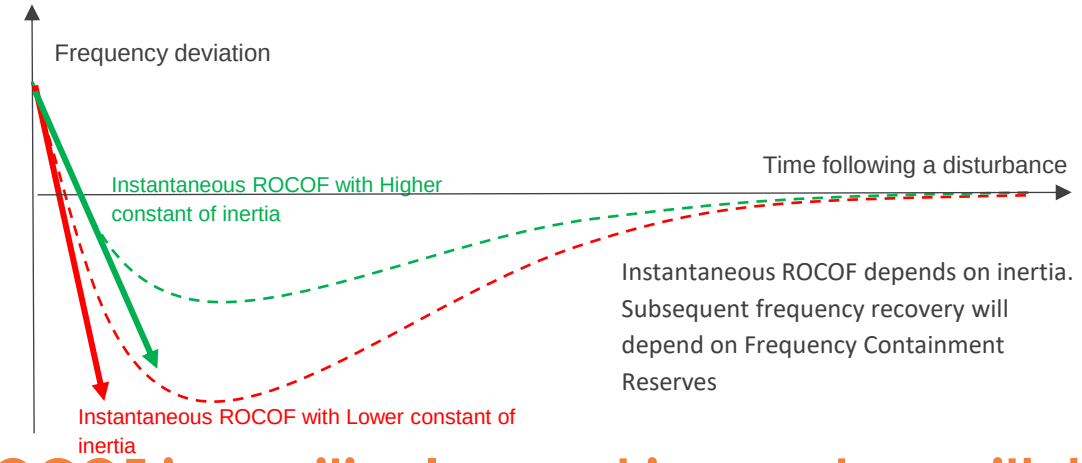
- **Very large units – contribute to largest infeed loss**
  - Frequency management challenges
  - Larger network disturbance when large unit lost in otherwise weak system
- **Traditionally not great contributor to reserves**
  - New nuclear capable – in principle yes, in practice? challenging on safety?
- **Can nuclear deliver fossil fuel equivalent flexibility?**
  - Needed at **NET** peak demand, not gross. Net = Gross demand – RES

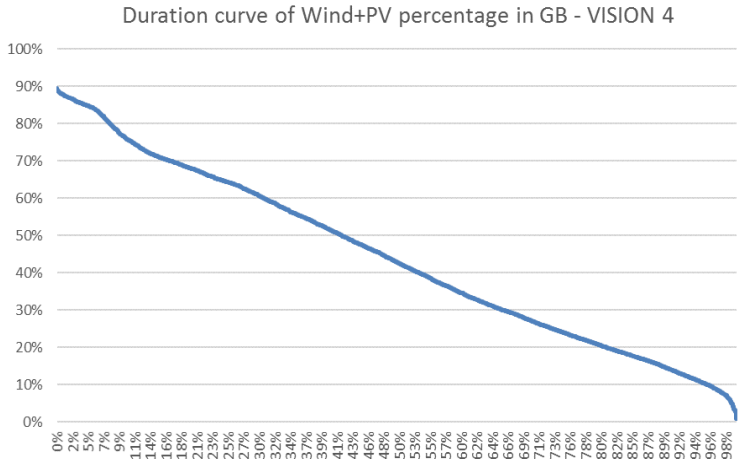
4 Opportunities to deliver solutions for networks / markets

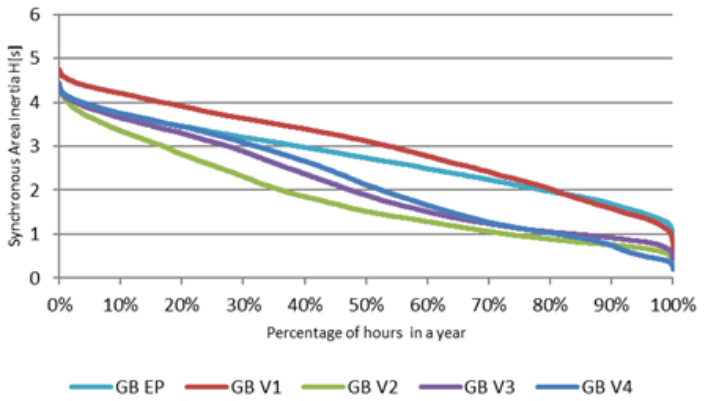
- **Firm capacity**
  - Need good availability during peak net demand, increasingly at short notice
  - Will market rules allow remuneration of capacity – in the long term?
- **Load following & reserves**
  - Opportunities to design in flexibility – these services expected to grow in value in market
- **Contribution to system strength services**
  - Contribute inertia to system, increasingly in short supply
  - Contribute to Fault Level (Short Circuit Ratio)
    - to retain adequate fault current for transmission protections
    - to help stability of all power electronics
  - Will ancillary services markets develop to remunerate these services in future?
    - Start being made of power electronics having to deliver contributions to these services

Contribute to inertia & hence frequency stability

- Analysis applied for the first time in TYNDP insight report “Viability of the energy mix”
- Country by country analysis recently used as a key reference in national guidance (IGD) on High Penetration of Power Electronic Interfaced Power Sources (HPoPEIPS)







ROCOF is a critical aspect in a system with high percentage of non-synchronous generation. It occurs immediately after a sudden imbalance in generation / demand

Concerning ROCOF, the system performance is mainly dependent on the available system inertia

Estimating inertia is used as an assessment proxy

5 Summary of desirable characteristics

- Energy when needed - reliable MW capacity
- Enhanced load following, deep (down to P=0.25pu) and fast
- Enhance high quality frequency regulating capability, particularly in small Synchronous Areas (e.g. GB's: dP>=10% in <10s) in addition to voltage regulation - for use during periods of low carbon dominance (when flexible fossil fuel is off).
- Continue to deliver system strength contributions through direct connected synchronous generators – FL contribution with voltage "clean-up" support
- Flexibility

" to be or not to be - that is the question"

Additional back-up material

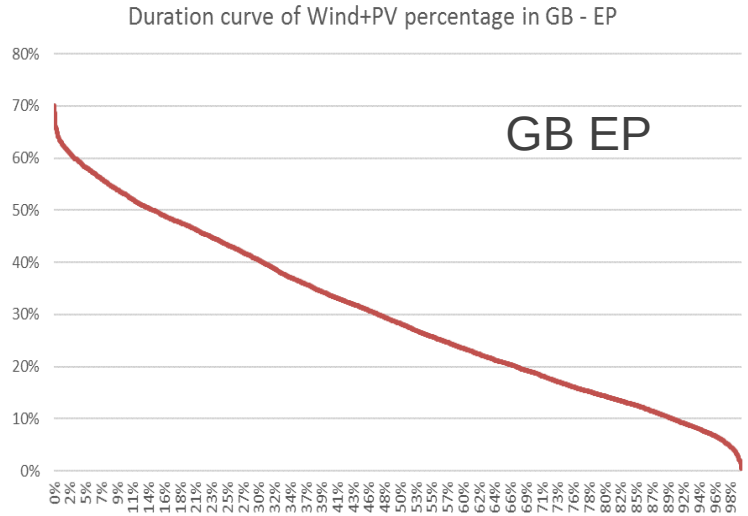
Not to be presented

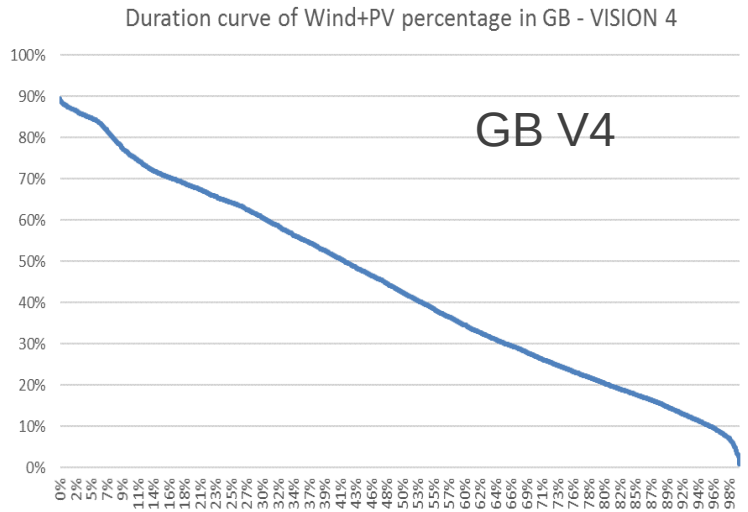
Background – Stability phenomena

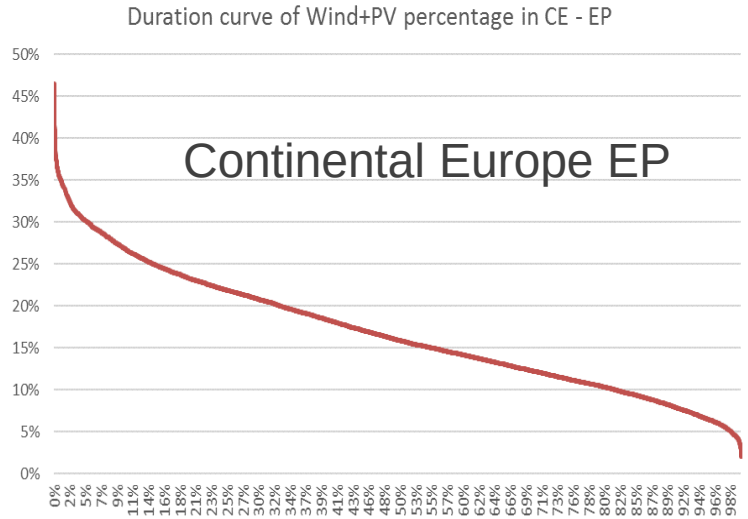
General principles - national/regional/pan-European analysis

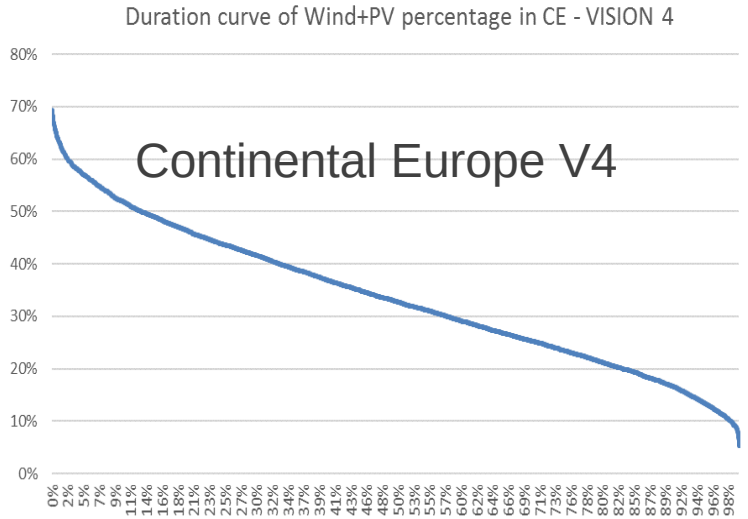
Stability Phenomena	Coordination	Level of analysis		
		TSO	Multi TSO	SA
Frequency stability	Analysis should involve all the TSOs of the synchronous area, as the model has to represent the overall system inertia with adequate representation of the frequency sensitivity of the connected devices.			X
Small Signal Stability	Analysis should involve all the TSOs of the synchronous area, as the oscillations identification methodology requires a detailed model for the whole system.			X
Voltage Stability	The phenomena are local or regional, so the analysis can be performed at TSO level. Nevertheless, neighbouring TSOs should be represented if their reactive power sources have a significant influence on the study area.	X	X	
Transient Stability	The phenomena are local or regional, so the studies can be performed at TSO level. Nevertheless, neighbouring TSOs system should be represented to an extent with a significant influence on the study area.	X	X	

Background – Frequency stability









Other indicators such as percentage of converter connected sources are possible

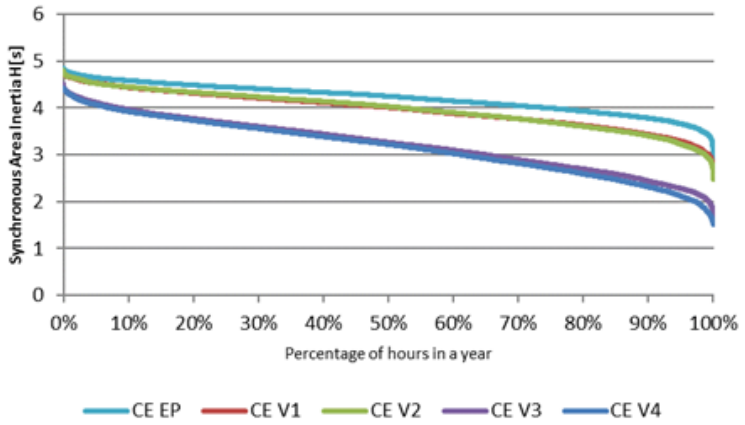
RES is calculated as the sum of wind and solar photovoltaic generation

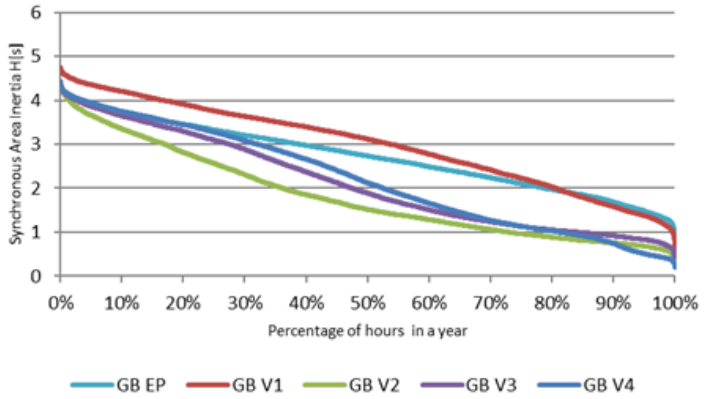
Indicator provides converter connected generation over the total generation

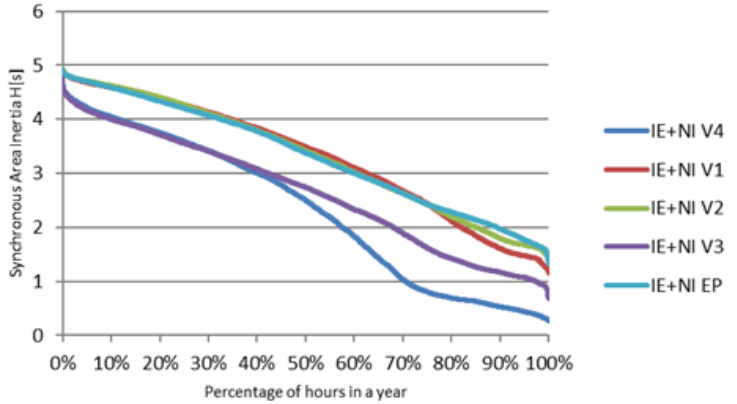
Results can also be presented per country

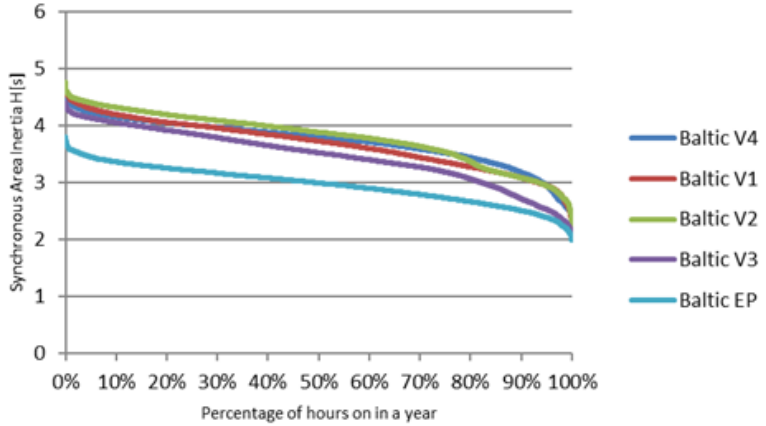
From DT PS *"Frequency feasibility checks on long-term TYNDP scenarios"* (link)

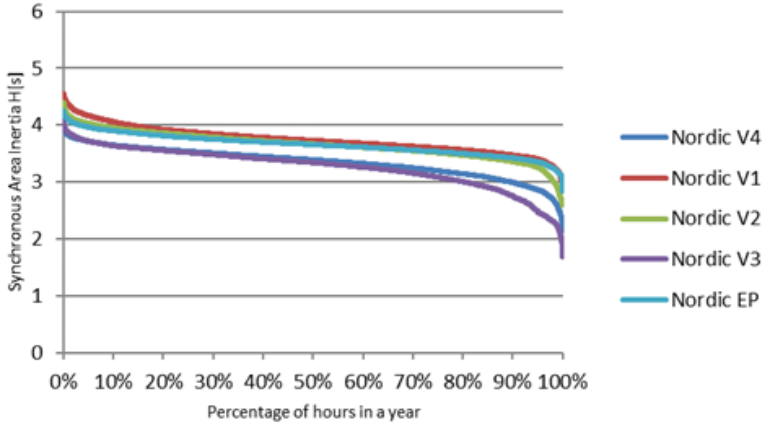
Background – Frequency stability







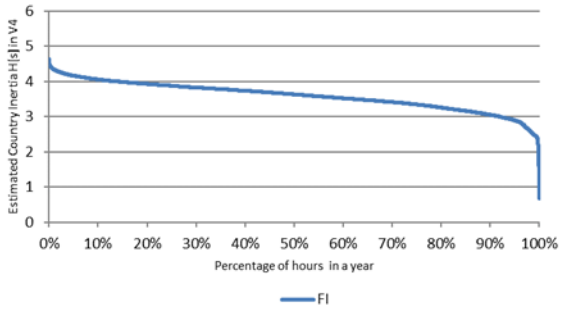


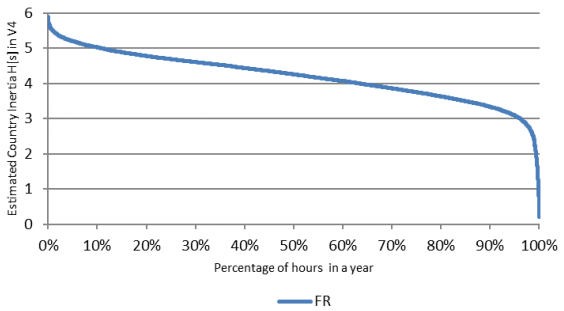


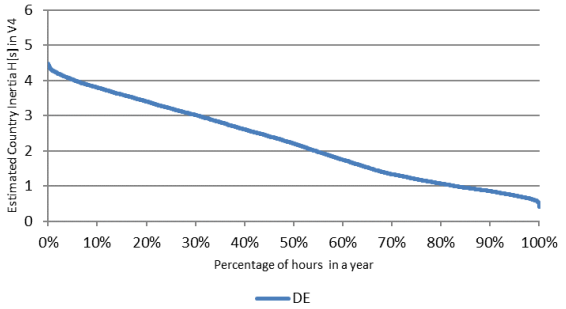
TYNDP 16 market study results for all synchronous areas and visions
Estimation of inertia can also be presented per country (V4 is exemplified in report)

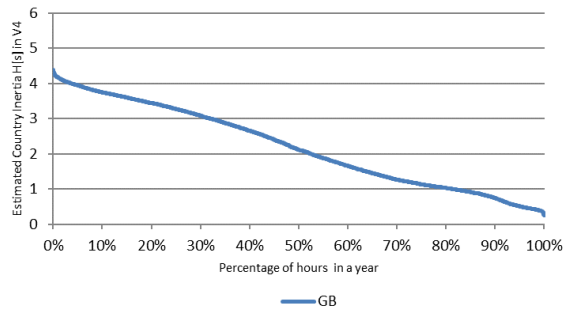
From DT PS *"Frequency feasibility checks on long-term TYNDP scenarios"* (link)

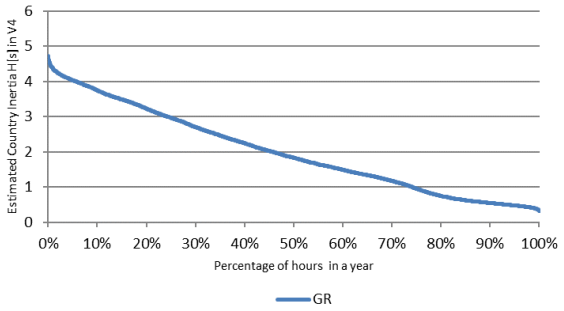
Background – Frequency stability

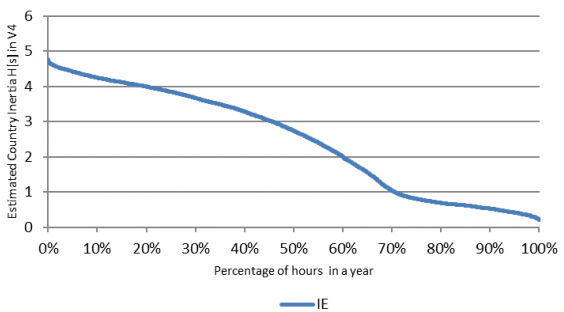


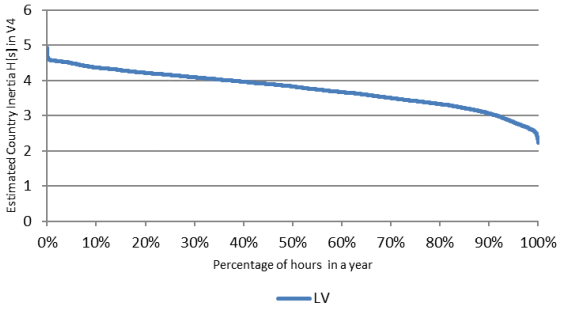


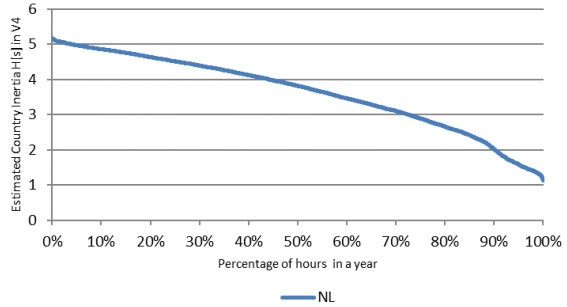


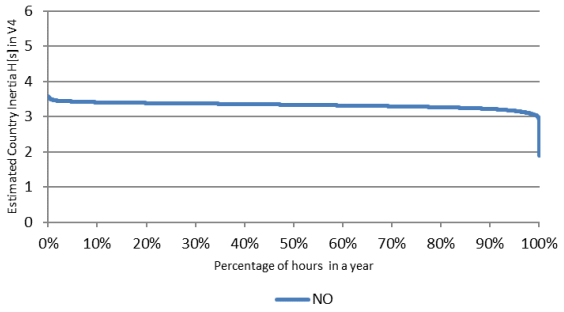


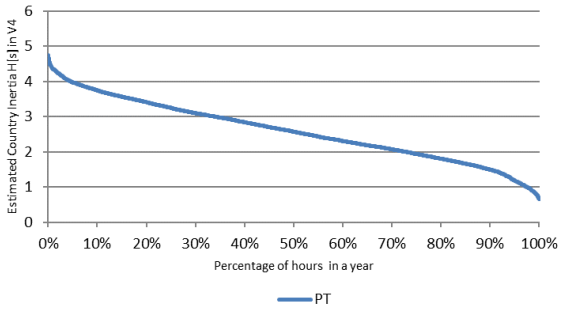


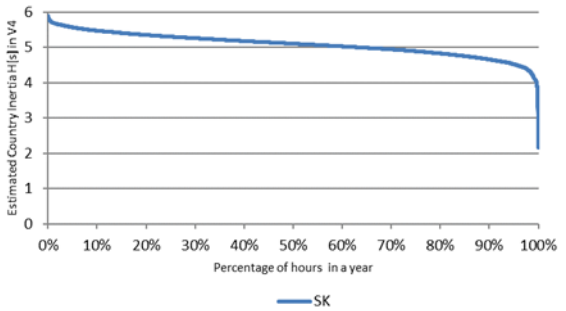












Estimation of inertia presented per country (TYNDP 2016 V4) Several examples…

From DT PS *"Frequency feasibility checks on long-term TYNDP scenarios"* (link)