IEA Bioenergy

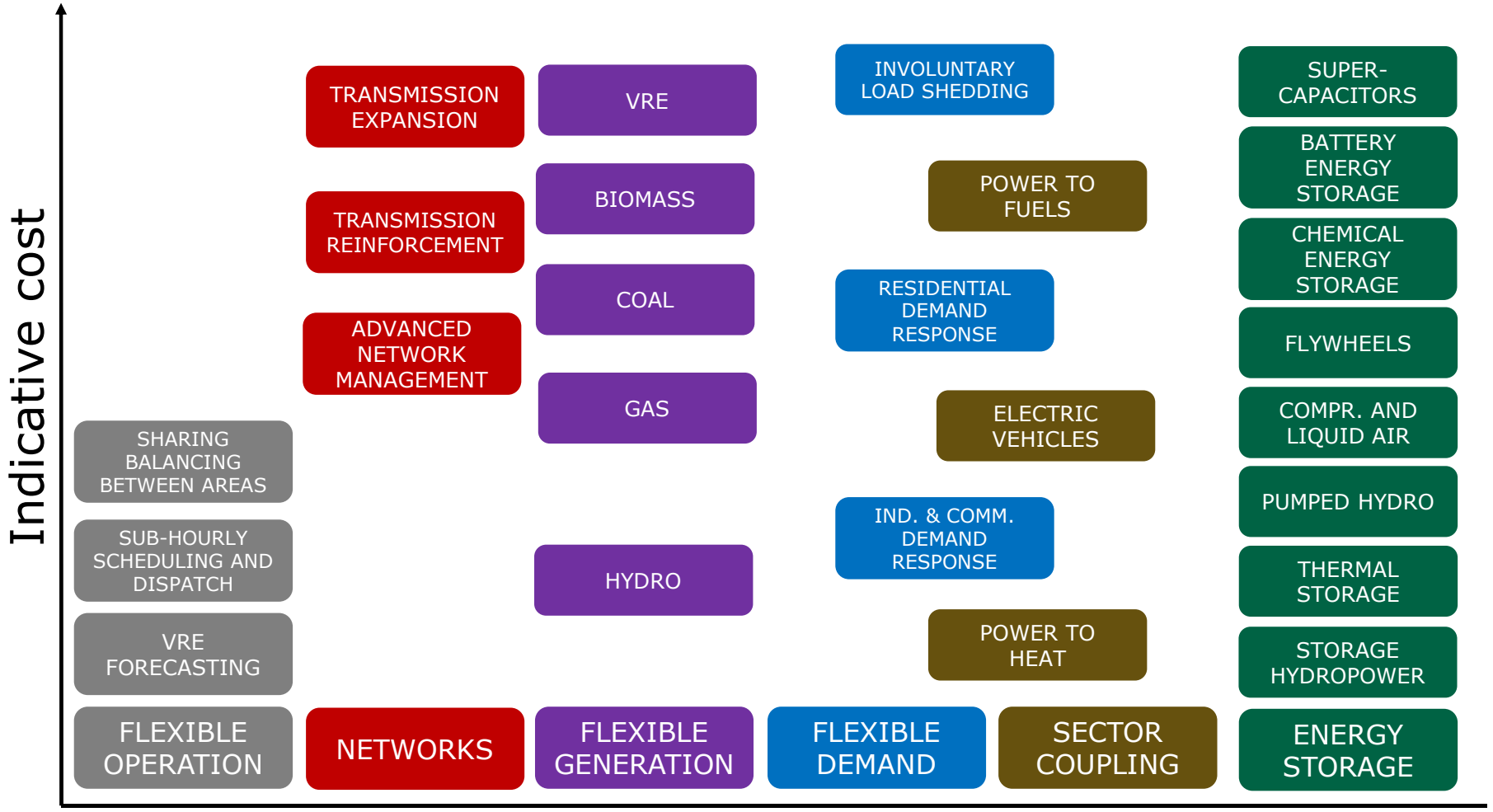
Flexibility options overview

Webinar: Inter-TCP meeting on Integrated Energy Systems, 6th April 2020

Ilkka Hannula, Task Leader
IEA Bioenergy TCP

Co-Authors: T. J. Lindroos, J. Kiviluoma, and H. Holttinen
With contributions from: A. Harby, A. Hauer and S. Adams

Categorisation of relevant flexibility options*

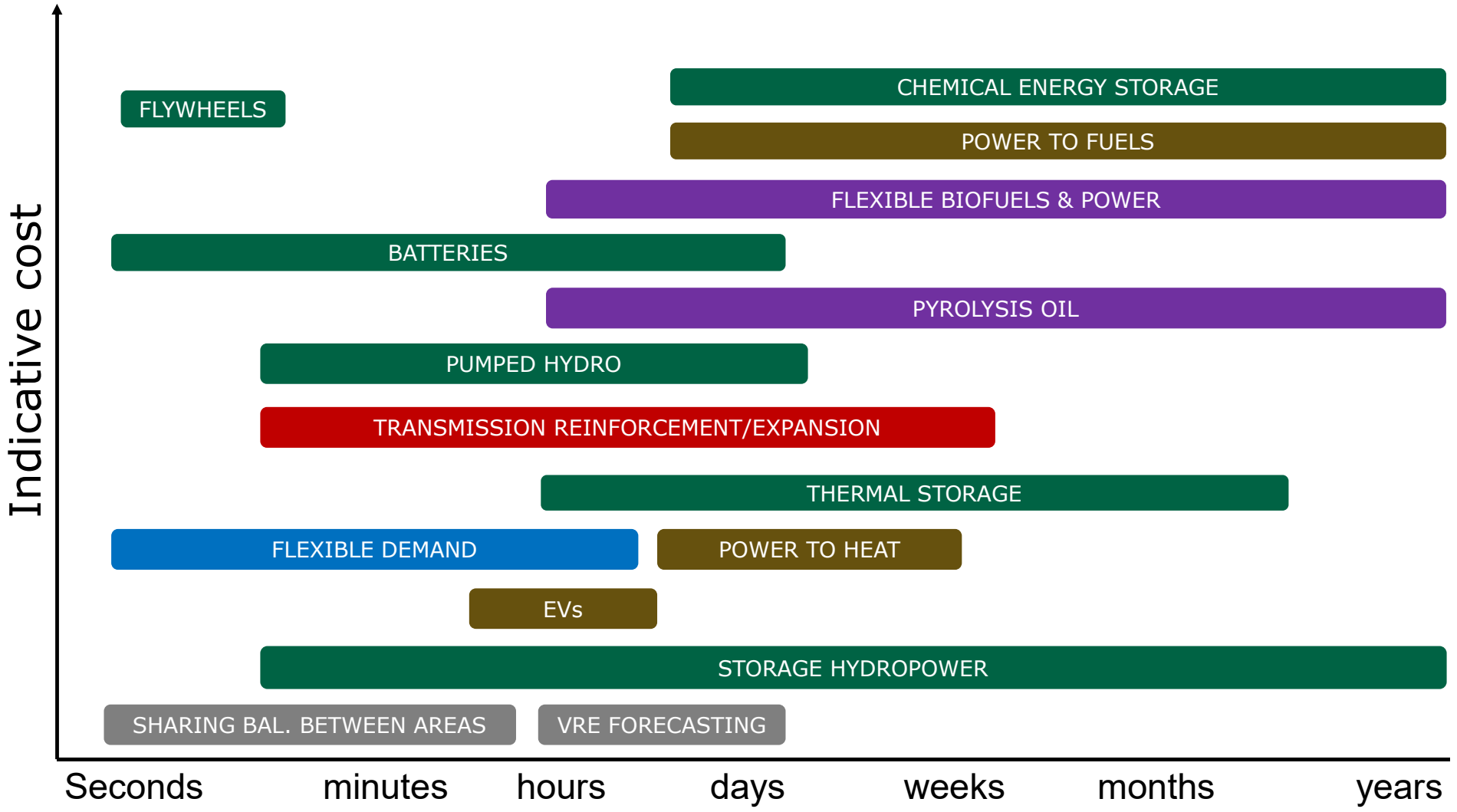


IEA Bioenergy

www.ieabioenergy.com

*Modified from Figure 7 of Flexibility in 21st Century Power Systems

Relevant time scales for selected flexibility options



SELECTION OF MATURE FLEXIBILITY OPTIONS

Flexibility option	Benefit	Capabilities	Sector and use	Potential/Limitation
Pumped hydro	Energy storage, ancillary services	Fast ramping, high power over several hours	Power; Short to medium term	Suitable sites, long lead times, environmental constraints, remuneration
Storage hydropower	Energy storage, backup capacity, ancillary services	Moderate ramping, large volume of storage/energy	Power; Short, to long term	Large volumetric storage needs. Suitable sites, environmental constraints
Thermal water storage	Thermal nergy storage (TES)	Low cost and long-term storage for thermal energy	Heat; Short to medium term	Large volumetric storage needs, limited to <100 °C.
Solid biomass boilers	Ramping, fuel storage, backup capacity	Minimum load: 15-30% Load change: 5%/min Cold start-up: 8-10 h Warm start-up: 4 h	Power & heat; Short to long term	Availability of sustainable biomass. Large volumetric storage needs

SELECTION OF EVOLVING FLEXIBILITY OPTIONS

Flexibility option	Benefit	Capabilities	Sector and use	Potential/Limitation
Flywheels	Ancillary services	Ultra-fast ramping	Power; Very short term	Installation anywhere. Security and costs
Compressed air energy storage	Energy storage	Moderate ramping, large volume of storage/energy	Power; Medium to long term	Costs, sites, environmental constraints
Battery energy storage	Ancillary services, energy storage	Fast ramping	Power; Short term	Easy to install. Sustainable materials
Power to heat/cold	Renewables to heating (& cooling)	High efficiency (COP~3) via heat pumps	Heating & cooling; Medium to long term	Availability of low-temperature heat sources
Pyrolysis oil	Back-up fuel & storage	Load change: 100%/20 s Cold start-up: 360 s Warm start-up: 150 s	Power & heat; Short to long term	Availability of sustainable biomass Currently TRL 5
Sector coupling	Flexible load from diff. sectors	Flow of energy between different sectors (power, heat, trans. & industry)	Heat, trans. & industry	Regulatory framework not prepared for this.
Flexible demand	Flexible load	Balancing demand to match the supply.	Residential, commercial, industrial	End user acceptance (residential sector), reg. & market design challenges

SELECTION OF EMERGING FLEXIBILITY OPTIONS

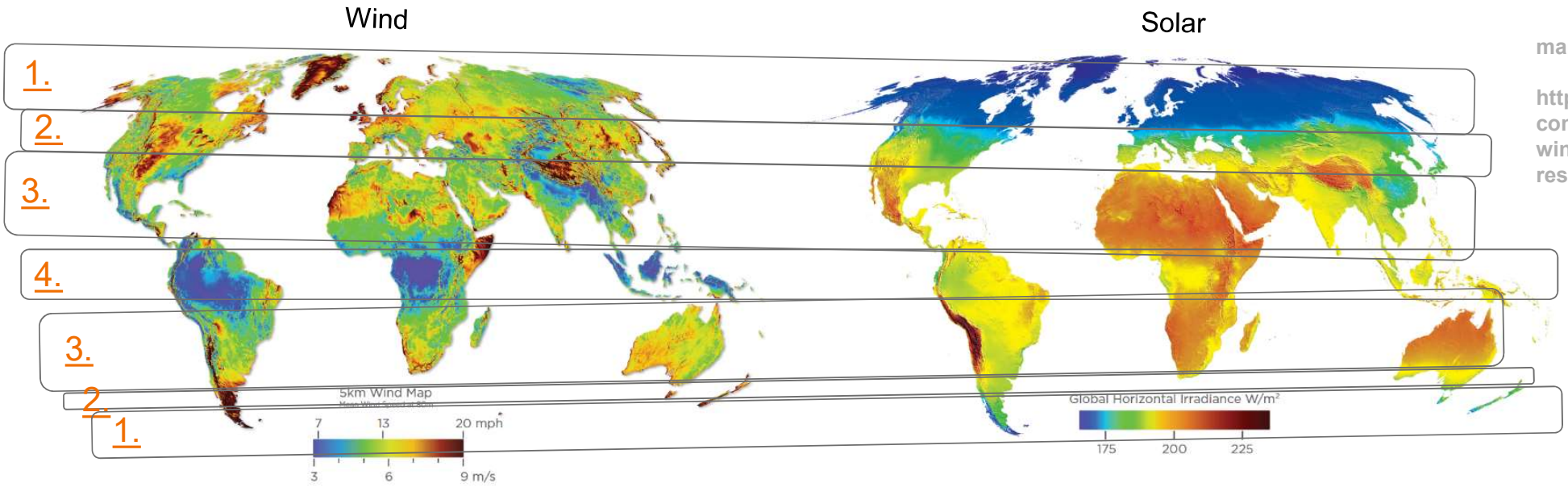
Flexibility option	Benefit	Capabilities	Sector and use	Potential/Limitation
Seawater and underground pumped hydro	Energy storage, ancillary services	Rapid ramping, high power over several hours	Power; Short to medium term	Ideal for islands/abandoned mines. Corrosion, environmental issues
Liquid air energy storage	Storage, ancillary services	Ramping and storage	Power; Medium term	Requires pressurised tanks and cooling energy
Power to fuels	Renewable chemical energy	Minimum load: 20% Cold start-up: 1-2 h Warm start-up: 1-5 min	Trans. & industry; Medium to long term	Availability of low-carbon, low-cost electricity Feasibility limit >4000 FLHs Low efficiency
Flexible polygeneration	Fuels or power	Load change: 100%/20 s Cold start-up: 360 s Warm start-up: 150 s	Power; Medium to long term	Number of adv. biofuel plants High biofuel value -> power generation unprofitable Currently TRL 5

IEA's "Six phases of system integration"

- Phase 1: No relevant impact on system integration
- Phase 2: Drawing on existing system flexibility
- Phase 3: Investing in flexibility
- Phase 4: Requiring adv. technologies to ensure reliability
- Phase 5: VRE surplus from days to weeks
- Phase 6: Seasonal or inter-annual surpluses of VRE

  -> Seasonal storage and use of electrofuels/hydrogen

Cost of flexibility vs. value of flexibility



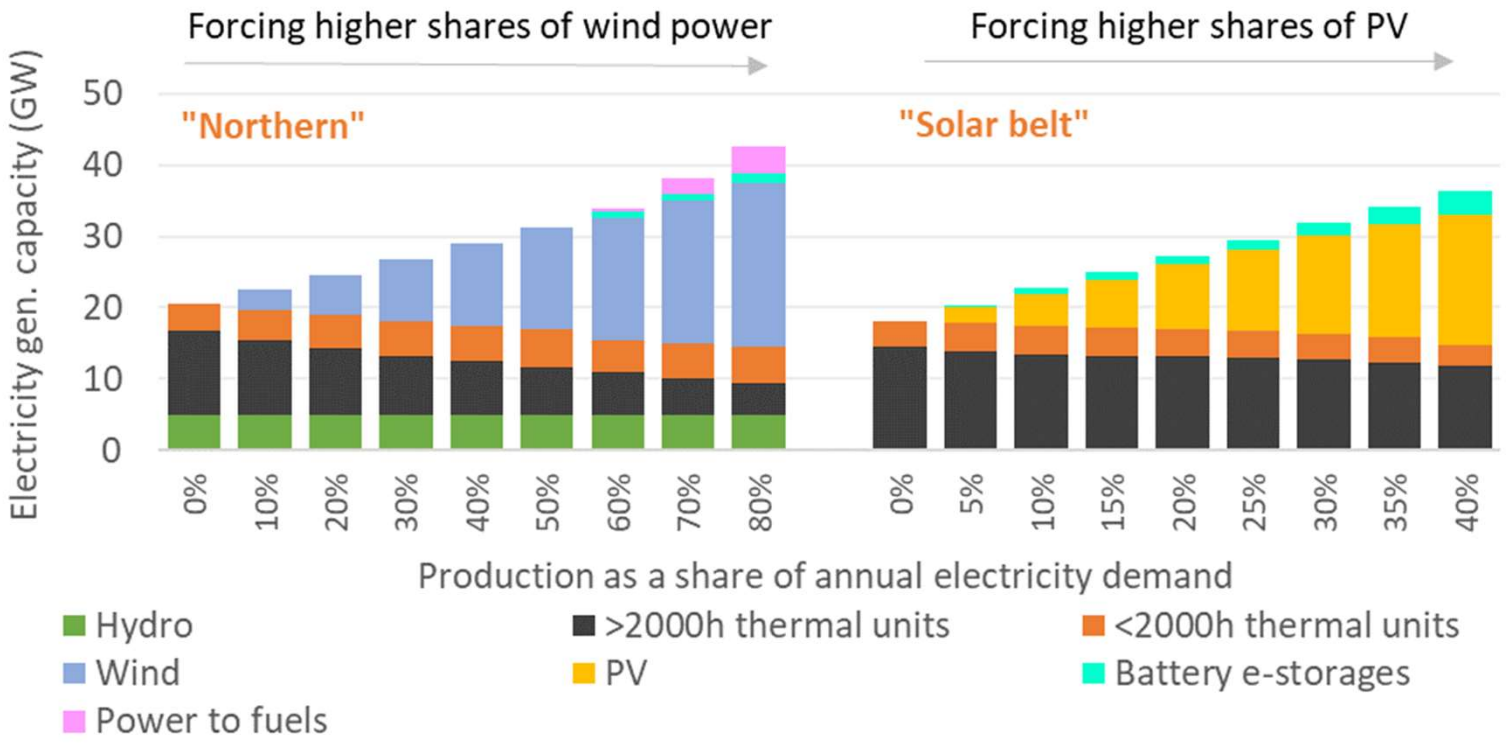
maps from VAISALA

https://www.vaisala.com/en/lp/free-wind-and-solar-resource-maps

Example system	Electricity demand characteristics	Hydro	Wind	Solar
1. Northern	Winter peaking system (Winter demand = 2.0x Summer)	Yes	40 % cf	11 % cf
2. Temperate	Winter peaking system (Winter demand = 1.9x Summer)	Yes/No	40 % cf	17 % cf
3. Solar belt	Summer peaking system w/ some heating (Summer = 1.5x Spring)	Yes/No	40 % cf	25 % cf
4. Tropical	Relatively flat demand (Winter demand = 1.3x Summer demand)	Yes/No	30 % cf	17 % cf

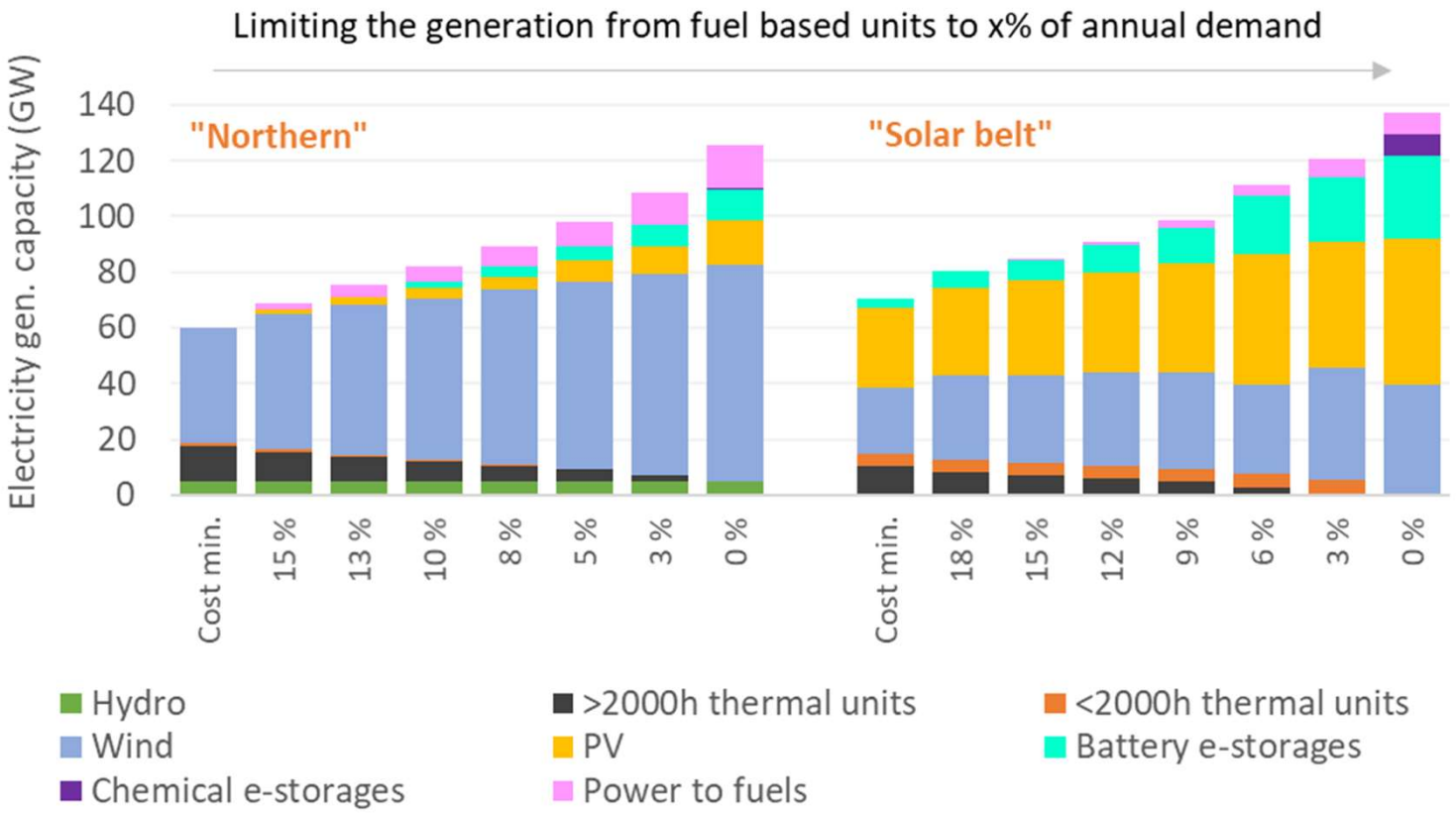
Impact of wind and PV increase on flexibility options

- Relative increase in peak units as variable generation (VG) increases
- Batteries balance day-night cycle of PV, Synfuels/H_2 appear only with very large amounts of VG
- Even large amounts of VG do not drive out thermal production



Impact of fuel phase out on flexibility options

- With limitations to fuel use, need for advanced flexibility options quickly increases
- Power-to-fuels capacity for Northern system
- Battery capacity for Solar Belt system
- Northern system utilises large storage of reservoir hydropower



R&D needs for flexibility options

- Increase flexibility of biomass boilers (lower minimum load & faster startups with good emissions performance and efficiency)
- Improving storability and quality of pyrolysis oil
- Develop and pilot ”flexible polygeneration” concepts for biomass
- Demonstrate integration of electrolysis with solid biomass processing
- New solutions to electrify industrial process, preferably with storage features
- Develop new types of RES hybrid technologies with flexibility features
- Retrofitting storage hydropower to increase capacity
- Remuneration and value of medium and long-term storage
- Capability (power, energy and ramp rate) of different flexibility options, and how hybridization can improve
- Increase flexibility of demand through automated demand response

Topics for further collaboration

- Better understanding of the value of different flexibility options in different contexts and at multiple time scales
- Better understanding on flexibility options that are resilient to various future outcomes
- Collaboration on developing hybrid solutions (e.g. solar-biomass, solar-hydropower, wind-biomass, wind-hydropower, batteries-hydropower)
- Further development (higher performance and lower cost) of all energy storage technologies with respect to their appropriate field of application

Thank you for your attention!

IEA Bioenergy

Contact Details

Dr Ilkka Hannula

ilkka.hannula@vtt.fi

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/

Additional material

Impact of fuel phase out on total system costs