Lessons Learned at 10th Wind Turbine Noise Conference Dublin, Ireland, June 2023 & related updates

Prepared for the Multi Municipal Energy Working Group

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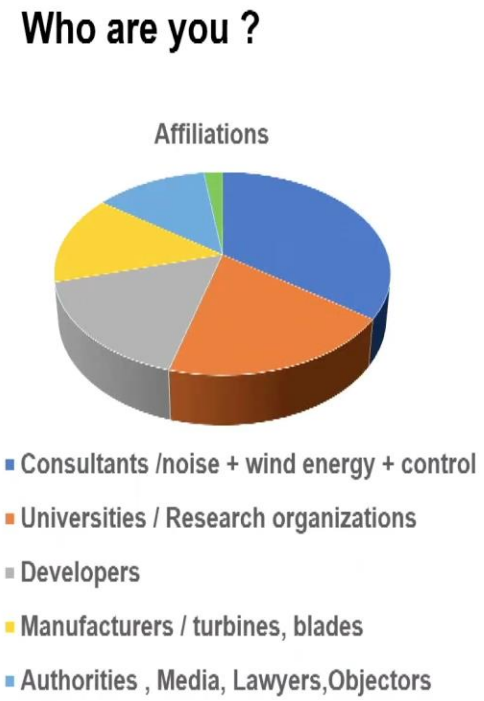
Overview – 10th International Wind Turbine Noise Conference (my 8th participation at WTN Conferences)

- 125 delegates attending at Trinity Business School, Trinity College Dublin Ireland, joined 30 attending remotely, in June 2023



44 Papers Presented at WTN 2023

(vs. 40 papers presented remotely in 2021, or 114 in person in 2015)

- Propagation (mostly about model development for sound travelling from the wind turbine to receptors) – 7 papers in a split session
- Mode Management (methods and the impact of reduction of turbine speed and output to reduce noise, when necessary to meet regulatory limits) – 3 papers
- Guidelines and Regulations – 5 papers
- Source Noise (mostly about models to predict the noise at the source, - the wind turbine) – 7 papers in a split session
- Impact on People – 8 papers in a split session (Including mine, presented remotely)
- Compliance (mostly about monitoring campaigns) – 4 papers
- Miscellany – Including Amplitude Modulation – 5 papers
- Tonal Noise – 5 papers

Key Learnings from WTN 2023

1. Forum – Wind Turbine Noise Reduction – Beyond Serrations
   - 4 panelists representing industry (Vestas, GE, Enercon, LM Blades)
     - Blades have to meet many needs, noise is only one, so pure noise optimization will never happen.
     - See no significant changes over next 10 years, as changes to reduce noise would increase blade complexity, increase risk of failure
     - Focus has been to reduce A-Weighted sound power by serrations, brushes, etc., on outer part of blades - perhaps need to consider larger inner parts of blades to reduce lower frequency sound reaching neighbours.
     - Industry agrees, may not be dealing with the real problem of what bothers neighbours, but are doing what regulators ask (to reduce A-Weighted “sound power”)
     - “angle of attack” changes as turbines rotate, changes sound profile around rotation
     - Could do better to reduce annoyance, but need to convince regulators to change focus.

Key Learnings from WTN 2023 – continued (2)

2. Tonal Reduction – Might be possible through tuned dampers
   - Several presentations focused on tonality in wind turbines, and how it might be reduced through modification of the turbine coupling & gearbox systems, or the addition of dampers.
   - Correspondence with the authors since the conference gave some hope that those experiencing tonality from Siemens turbines at K2 and Armow might benefit from modifications, but the suppliers are cautious to make any predictions. Further follow up with K2 and the Ministry is possible, but not done yet.

Key Learnings from WTN 2023 – continued (3)

3. Follow the money to find the problems
   - While not a specific paper topic, this theme was just below the surface in most
   - An obvious example arose in a presentation about WTN standards in Chile
     - Citizens, who will experience the turbines 24/7 – 365 days a year will have protection at a level of either background plus 10 dBA, or 65 dBA in the daytime and 50 dBA at night .
     - Tourists, who will experience the turbine noise only for the duration of their visit, will experience a level to not exceed background (10 dB less than citizens). Is this fair?
     - But, sending tourists away would cost money.
   - Similarly in many other presentations, action is based on profit.
     - If no money will be earned, then no action occurs.

Key Learnings from WTN 2023 – continued (4)

4. Worldwide, standards are softening to allow more turbines
   - International Energy Agency requires more wind power developments to meet the carbon limits set by the Paris 2015 Climate Change Conference.
   - Paper from the Netherlands noted all their national wind turbine regulations have been dropped, and they are reconsidering all setback limits.
   - Example, Poland has reduced limits from 10x height setback (perhaps 2400 metres), to 700 metres, regardless of turbine size. Required of Poland by the EU, “to receive European funds under the national recovery plan.”
   - State of Bavaria (Germany) reducing setbacks from 10X height to 800m in “wind priority areas” to “catch up in the production of wind energy.”
   - Other nations were noted as having limits of 4x height. The main criteria for setback was noted to be “to prevent visual nuisance”, or “visually overwhelming effects.”

Key Learnings from WTN 2023 – continued (5)

5. Population Effect vs. Individual Effect

- Regulators appear to be more interested in *possible* overall population effect, than in *known* impact on the fewer people living near turbines.
- Example – following 3 presentations on "mode management" to optimize output while meeting sound limitations, David Michaud of Health Canada stated,
  - *"It seems very strange to me that you'd want to use modes to reduce the power output in the first place. Because, presumably you want to offset fossil fuels burned with clean energy, and by reducing the mode … you increase the percent required from fossil fuel required by the electrical grid … so the net health effect on the population could be worse when you are reducing power output … You are using modes to reduce exposure … presumably because that annoys people that might interfere with sleep … but by reducing sound level you have get power from somewhere else."*
  - He continued, *"why not just … for every minute or hour above the limit, if we distribute some benefit to the community, and leave the turbines alone ?"*
  - The session chair countered, *"David, you will have to give a presentation at some time, and argue that more noise is beneficial to the community."* There was a general chuckle from the audience.

Hopefully, a Key Learning for others came from my paper, re *"developing a measurable objective for wind turbine annoyance"*

- Began noting that annoyance from wind turbines is not going away

WTN Conference	Total # of Papers	# of Mentions of "Annoyance"
WTN 2005	29	78
WTN 2013	72	406
WTN 2021	40	438

- The paper's stated objective was to replace a "subjective" assessment of annoyance with an "objective" (measureable) one.

It began, from listening to hurting people

- They tell us of:
  - Behavioral changes in domesticated animals (horses, cows, goats, etc.)
  - Difficulty in falling asleep or in going back to sleep after awakening – condition goes away if they leave home, yet comes back when they return
  - Digestive issues, nausea
  - Headaches
  - Changes in control of diabetes, or blood pressure regulation
  - Tinnitus
  - Changes work schedules, work life, or residence
  - Specific troubles from freezing rain, or hot, still summer nights

Next, we looked at data already on hand

- Spot measurements taken near, and far, from wind turbines since 2007
- Short duration attended recordings near turbines since 2011
- Two years of continuous acoustic recordings from mid 2018 to mid 2020 at one site ~ 787 m from the nearest wind turbine, and local spot recordings at a second site in the same array
- 9 months of continuous acoustic recordings from a site ~ 537 m from the nearest wind turbines (of a different type) from 2020 through 2023, along with some simultaneous recordings > 6 km from the same wind turbines
- Resident complaint data filed with the Ministry of the Environment at the sites near wind turbines
- Could any link be established between the complaints and the sound?

Data analysis suggested a hypothesis

- Most people will perceive a 3 dB change in dBA value
- Considered cases where the difference between LA90 (considered as background levels) and LA10 (typically the loudest sounds occurring ≤ 10% of the time) is ≤ 3dB as representing those cases that might not readily be perceived
  - Looked for simultaneous cases when the spectrum including low frequency showed LZ10-LZ90 is ≥ 6 dB (two 3 dB changes, potentially more readily perceived)
- There was a good match – between the annoyance complaints and the recorded conditions at the time of the complaint matching those conditions, suggesting a possible hypothesis:

Annoyance can be predicted for LZ10-LZ90 ≥ 6 dB while LA10-LA90 ≤ 3 dB

- Set out to prove this hypothesis.

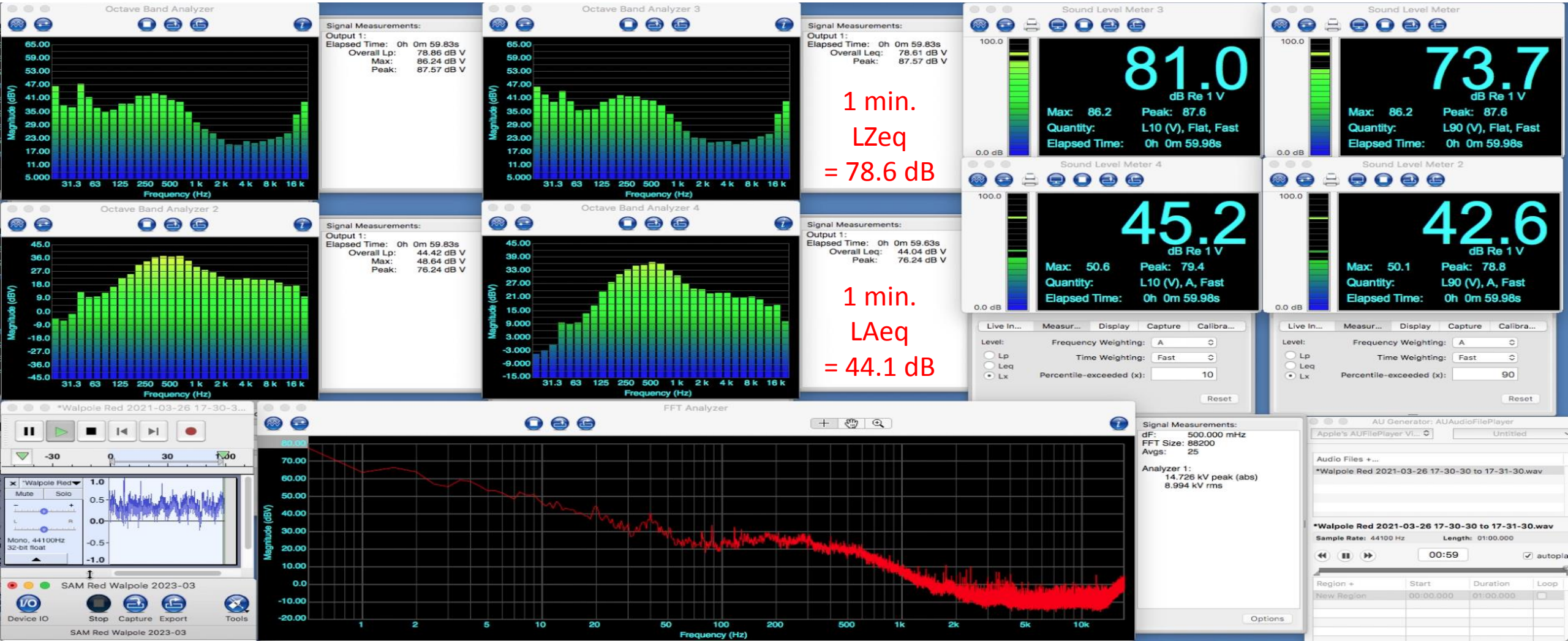
Displayed analysis of an example

(Categorized by resident as annoyance level 7/10)

For this case, analysis showed:

LZ10 (81.0) – LZ90 (73.7) = 7.3 dB

LA10 (45.2) – LA90 (42.6) = 2.6 dB



Tested if the results could just be the wind?

- Closely examined data from times turbines shut down or started up (as wind speeds do not change appreciably over the short transition)
- Also compared data recorded simultaneously at the site ~ 537m from turbines, and at a site > 6 km to the same wind power array
  - same terrain, same proximity to roadways, closely matched environmental conditions (wind, temperature, pressure, humidity, precipitation, etc.)
- Tested analysis microphones against Level 1 IEC 61094-4 compliant microphone
- Extended data set to test at regular 1 or 2 hour intervals, to ensure not only testing complaints, but sampling all conditions
- Looked at months of data

Is it the Turbines? Here is a case of running / shutdown / running

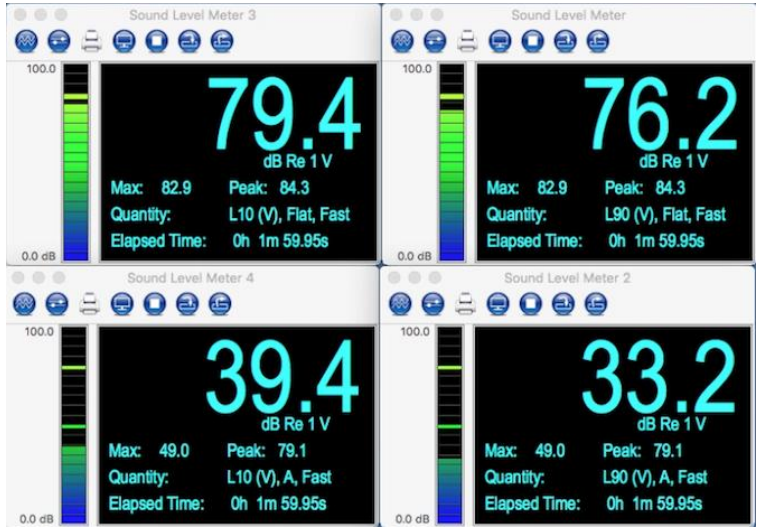
2021-03-25 – An example over 2 hours (turbines at low power) logged at same location

13-38 to 13-40 Turbines Running

LZ10-LZ90 = 83.8-72.5 = 11.3 dB

LA10-LA90 = 43.8 – 40.8 = 3.0 dB

14-10 to 14-12 Turbines Not On



LZ10-LZ90 = 79.4-76.2 = 3.2 dB

LA10-LA90 = 39.4 – 33.2 = 6.2 dB

Note drop in LZ10 & LA90

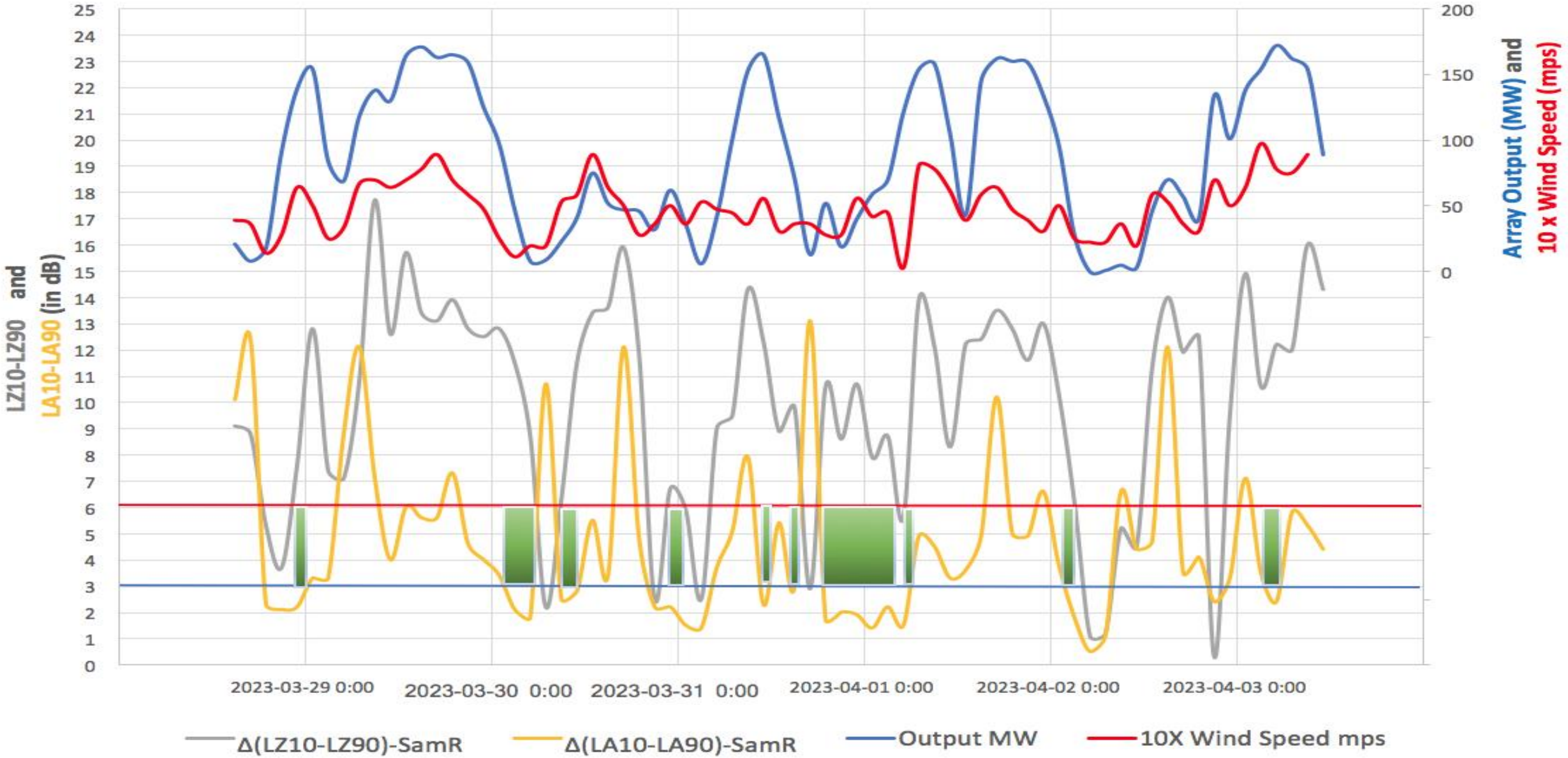
15-55 to 15-56 Turbines Restarted still at very Low Power

LZ10-LZ90 = 82.8 – 73.5 = 9.3 dB

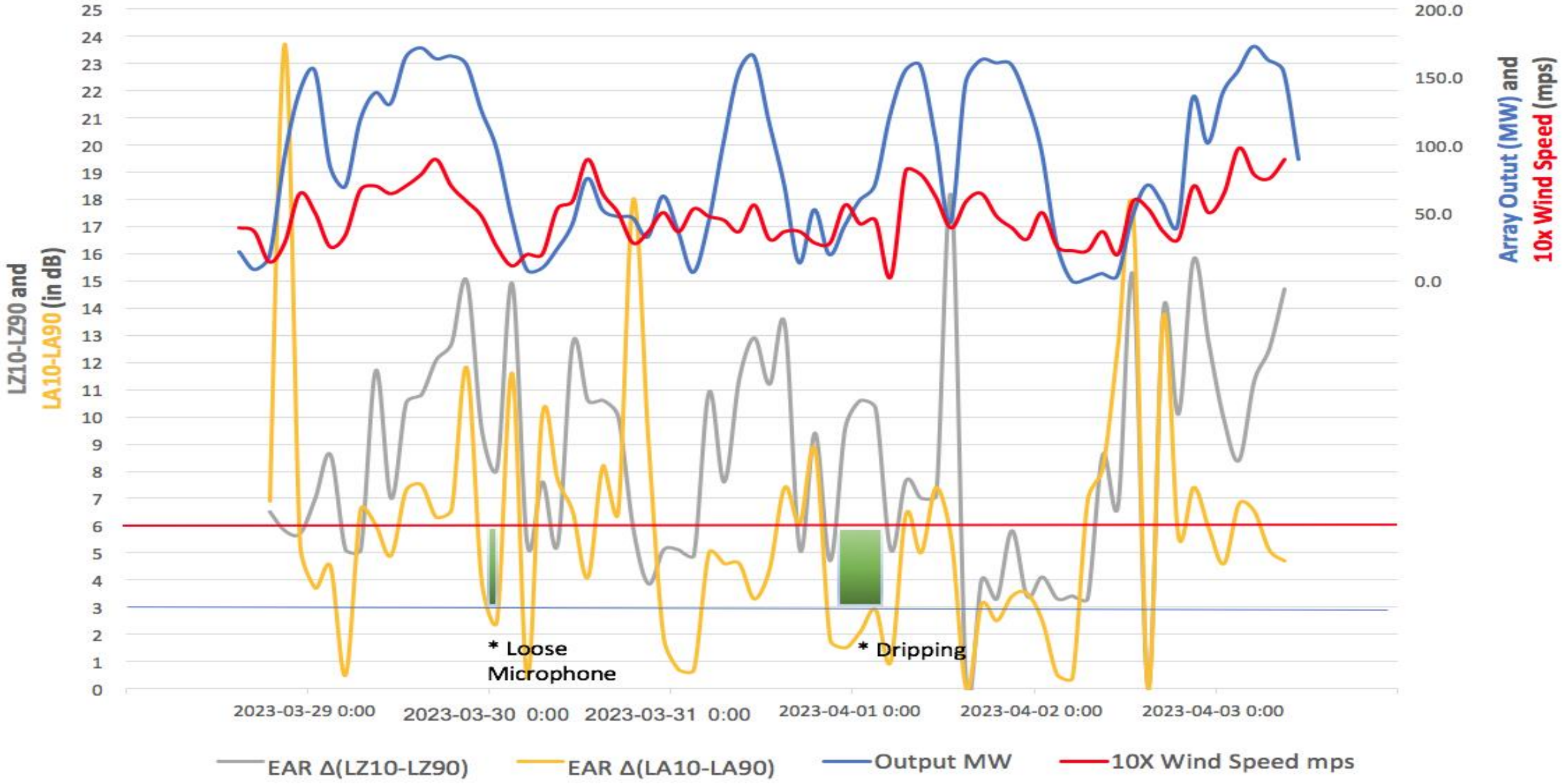
LA10-LA90 = 38.3 – 36.7 = 1.6 dB

LZ10 & LA90 are up again

Occasions meeting criterion LZ10–LZ90 ≥ 6 dB and LA10–LA90 ≤3 dB when ~ 537m from nearest wind turbine



Occasions meeting criterion LZ10–LZ90 ≥ 6 dB and LA10–LA90 ≤3 dB when > 6 km to nearest wind turbine



Conclusions

- The annoyance criterion LZ10-LZ90 ≥ 6 dB while LA10-LA90 ≤ 3 dB tends to match actual annoyance reports, by detecting situations when wind turbines dominate the environment.
- While it does not replace criteria for assessing LAeq, tonality, or accurate measurements of amplitude modulation, it is quick to assess, and is useful for screening to predict annoyance.
- It can be a useful additional tool in the regulatory tool-kit to predict & assess when citizens may be impacted by wind turbine annoyance.
- There is a real basis for annoyance reported from wind turbines.

Other Papers – Already Delivered

- Delivered template to Rep. Carrie Barth, Kansas Legislature at her request, as input for presentation to Shawnee County Planning Commission regarding proposal to increase number of wind turbines in Kansas.
  - Kansas specifics, state population of 2.9 million, has ~ 4000 wind turbines now (8240 MW), supply nearly 50% of their electrical consumption (caution, a lot of this is exported, while coal, nuclear, and gas fill in day to day needs)
  - The usual realities of lower wind output in Jan,Feb / Jul,Aug while high in Mar,Apr, Oct, Nov. resulting in export. Discussed storage not viable for seasonal shift.
  - Discussed public health concerns & setbacks:
    - As general rule, limit total sound emissions received at a residence to < 35 dBA, and < 50 dBZ.
    - A setback of 1 mile (5280 feet, 1610 metres) would limit emissions received at residence to < 35 dBA, and < 50 dBZ for today's turbines if more than 1 turbine possible.
  - Discussed public safety risk and setbacks (used Ontario failure data of 12 failures)
    - Needs safety setback of 400 metres (1/4 mile or 1320 feet) from turbine
    - Ensure any turbines permitted have integral fire protection
    - Consider rights of leaseholder to waive rights for others (vulnerable family, employees, contractors)
  - Discussed storage
    - Remember storage consumes energy, and all energy consumed increases heat in the world (global warming)

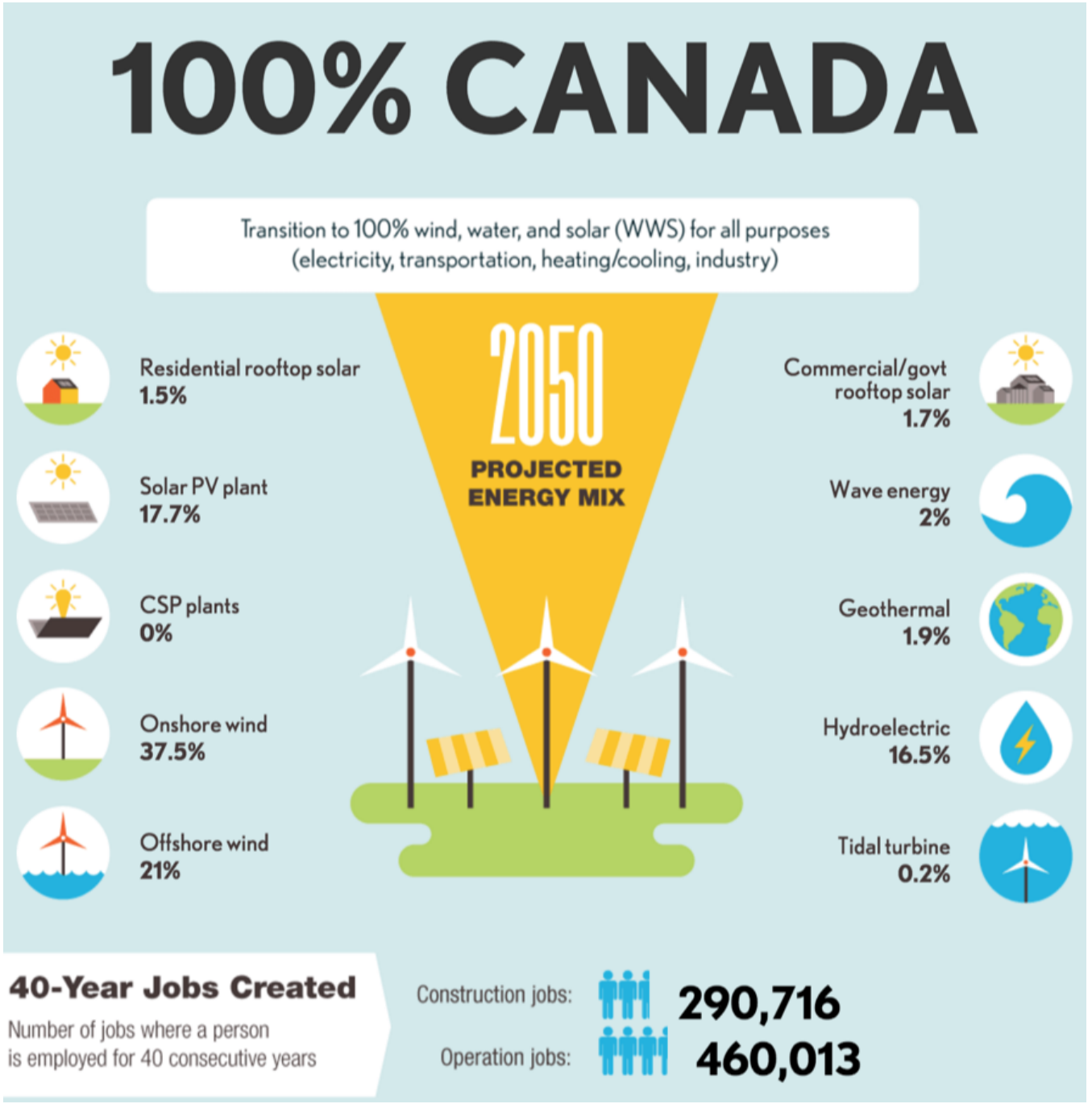
Other Papers – Upcoming - Acoustics

- Acoustics Week in Canada (Canadian Acoustics Association)
  - Montreal Oct. 3-6
  - Paper - **LESSONS LEARNED MONITORING NEAR AND FURTHER FROM WIND TURBINES**
  - Will present follow-up results from paper presented at WTN 2023
  - Data gathered, acoustic, environmental, and wind turbine performance.
  - Resident annoyance level, showing development of screening criterion useful to identify when annoyance will occur
  - To be published in the Journal - Canadian Acoustics (peer reviewed)

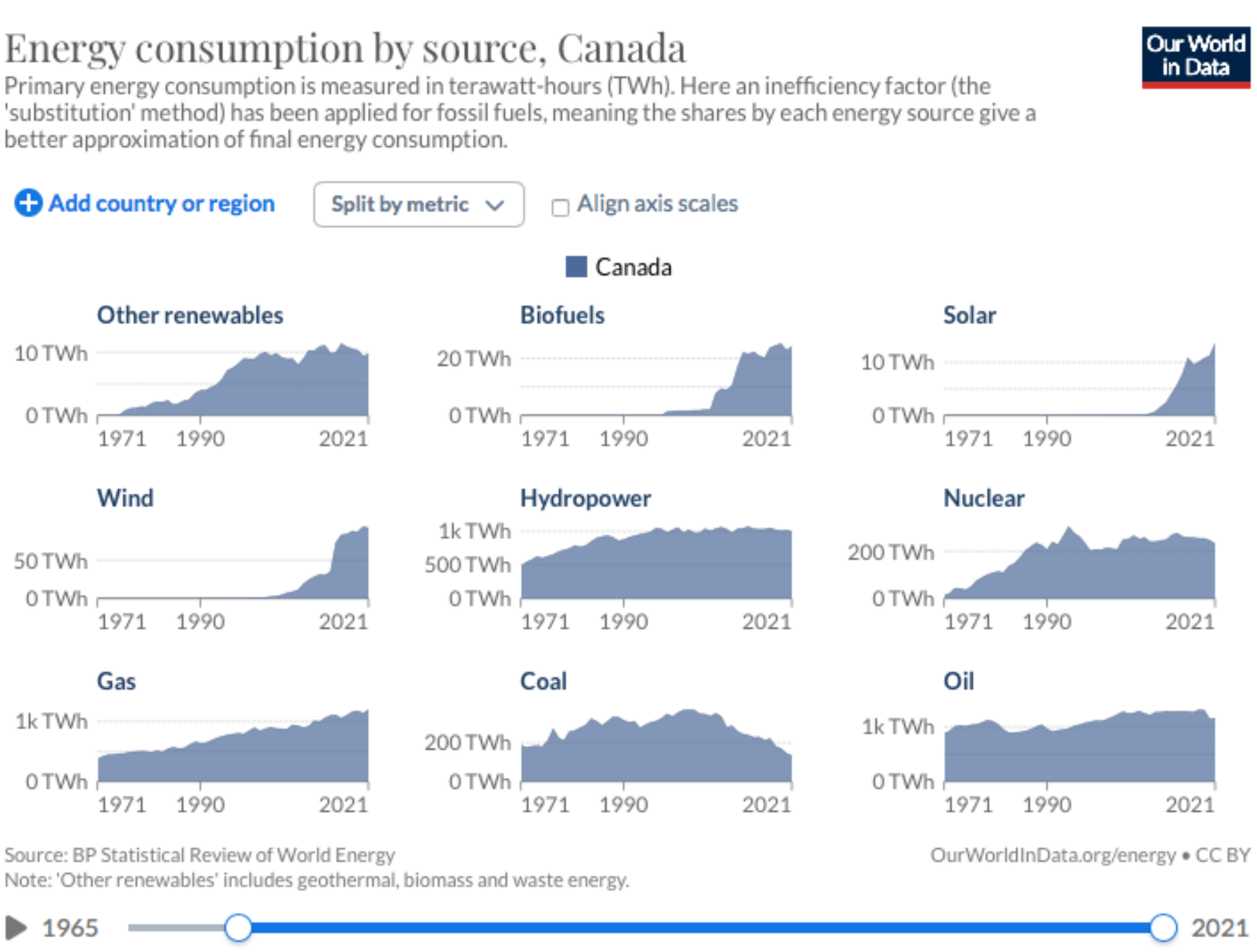
Also Upcoming Presentation – Energy Supply

- Requested by Ontario Society of Professional Engineers to present continuing education module to a “Thought Leadership Thursday” Oct. 12 on the subject, “Understanding the Challenges Facing the Ontario Electrical System.”
- Will try to bring some reality into the global objective stated in 2022 by UN Secretary General António Guterres, for the supply of renewables of water, wind, and solar to double by 2030, and to double again by 2050.
- Canada has an even more challenging objective, to transition to 100% wind, water, and solar for all purposes (electricity, transportation, heating/cooling, and industry) by 2050.
- But, numbers show us that in 2019 (latest data available) electricity supplied 16% of Ontario’s energy needs, while petroleum and natural gas supplied 76%. Meeting the objective of 100% supply from renewables of hydro wind, and solar by 2050, is well, challenging.

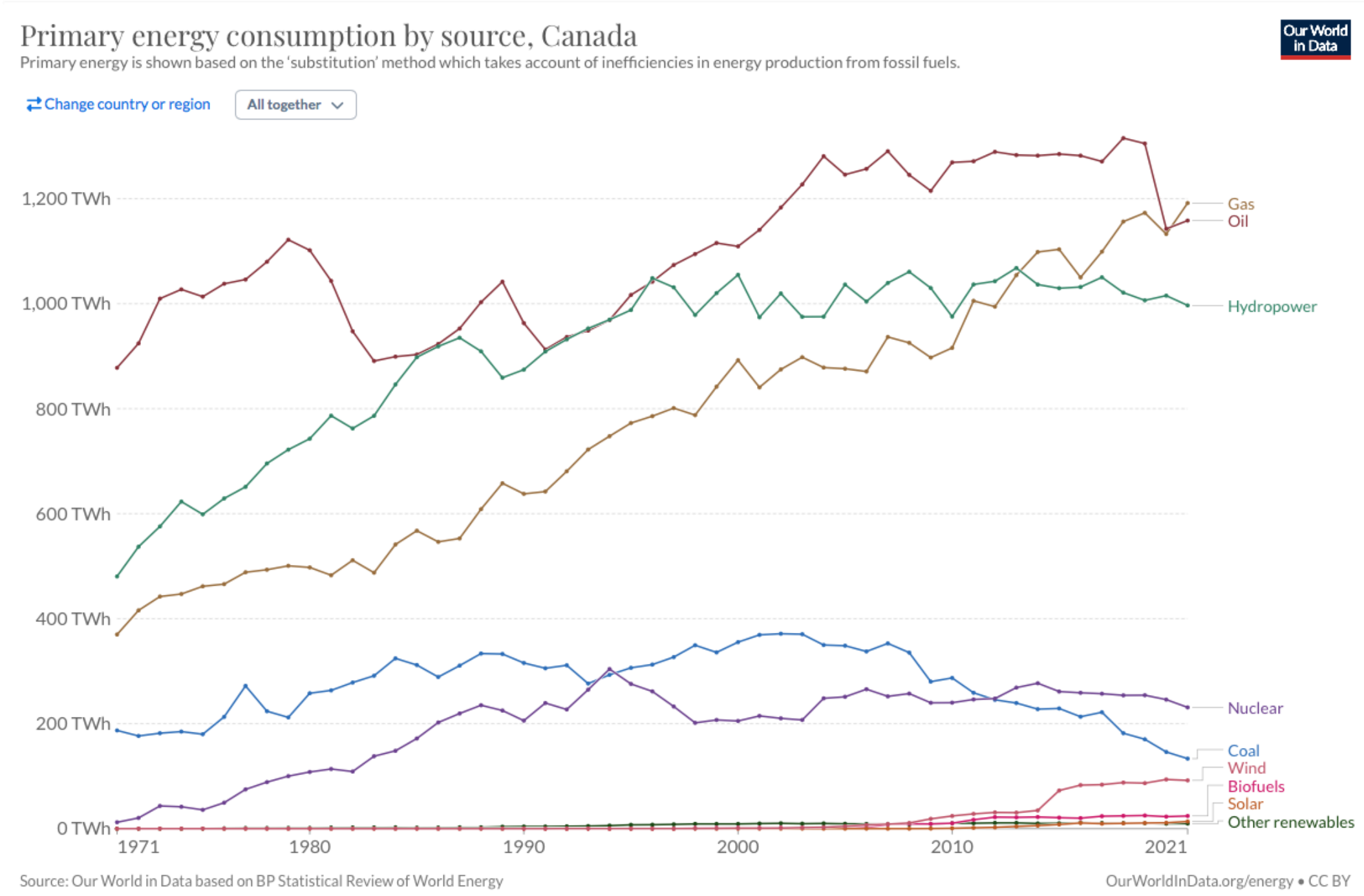
Canada's Goal:



Leaders Love This Slide



They Forget Reality

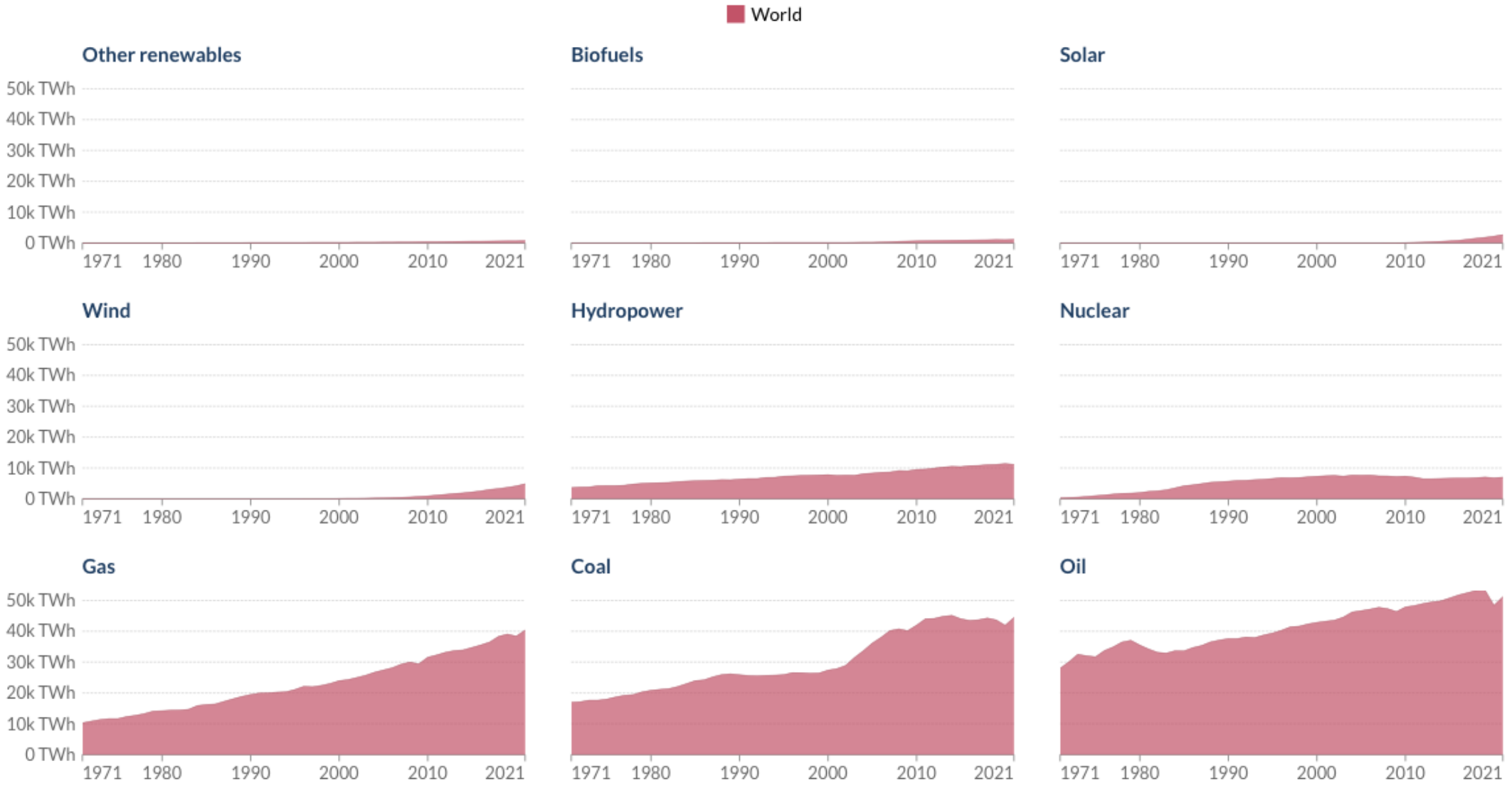


Energy consumption by source, World

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.

Our World in Data

Add country or region | Split by metric | Align axis scales



Source: BP Statistical Review of World Energy
Note: 'Other renewables' includes geothermal, biomass and waste energy.

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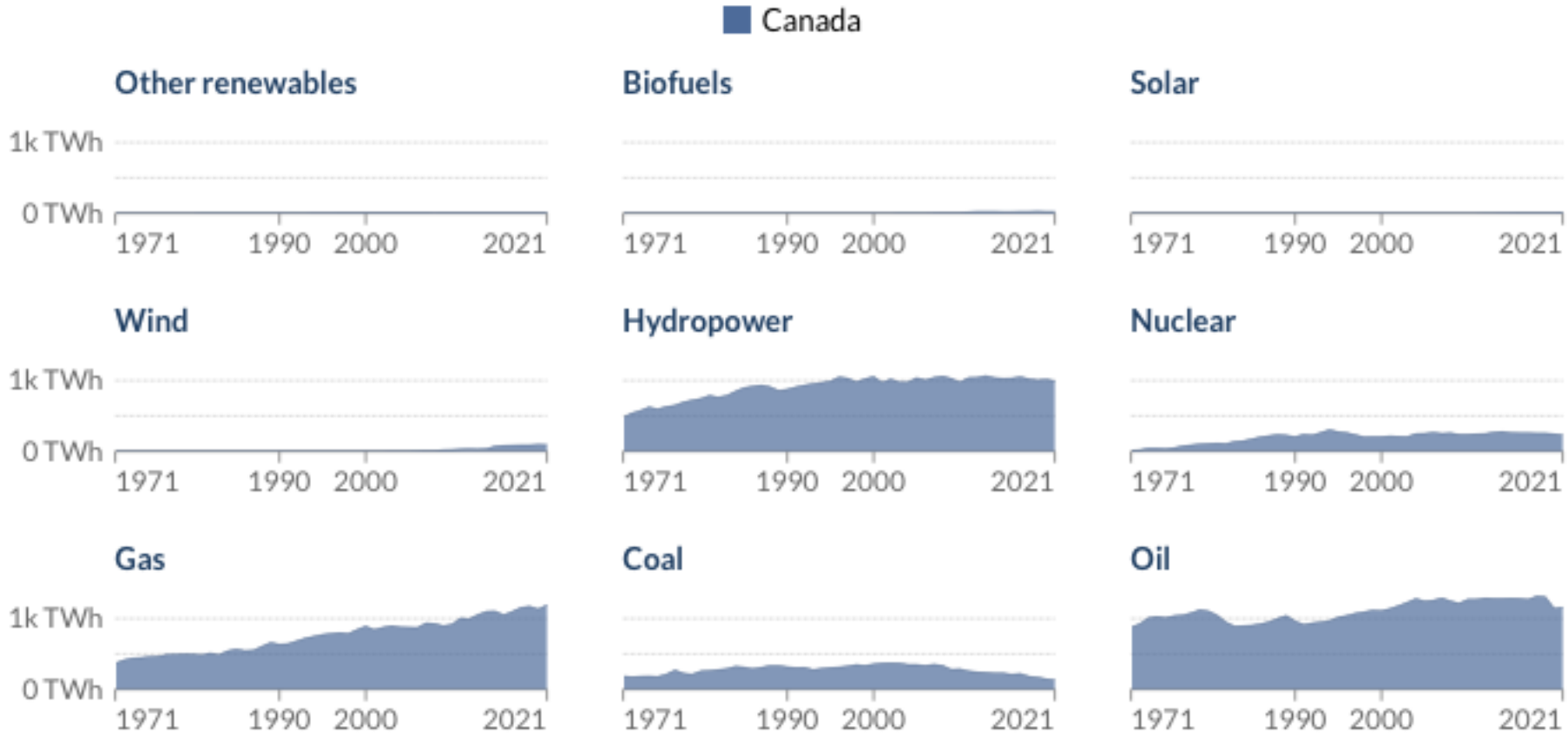

Source: BP Statistical Review of World Energy

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1965 — 2021