

# Environmental impact of digital tech: *spectrum environmental efficiency*



Tim Unwin

WIRELESS WORLD  
RESEARCH FORUM

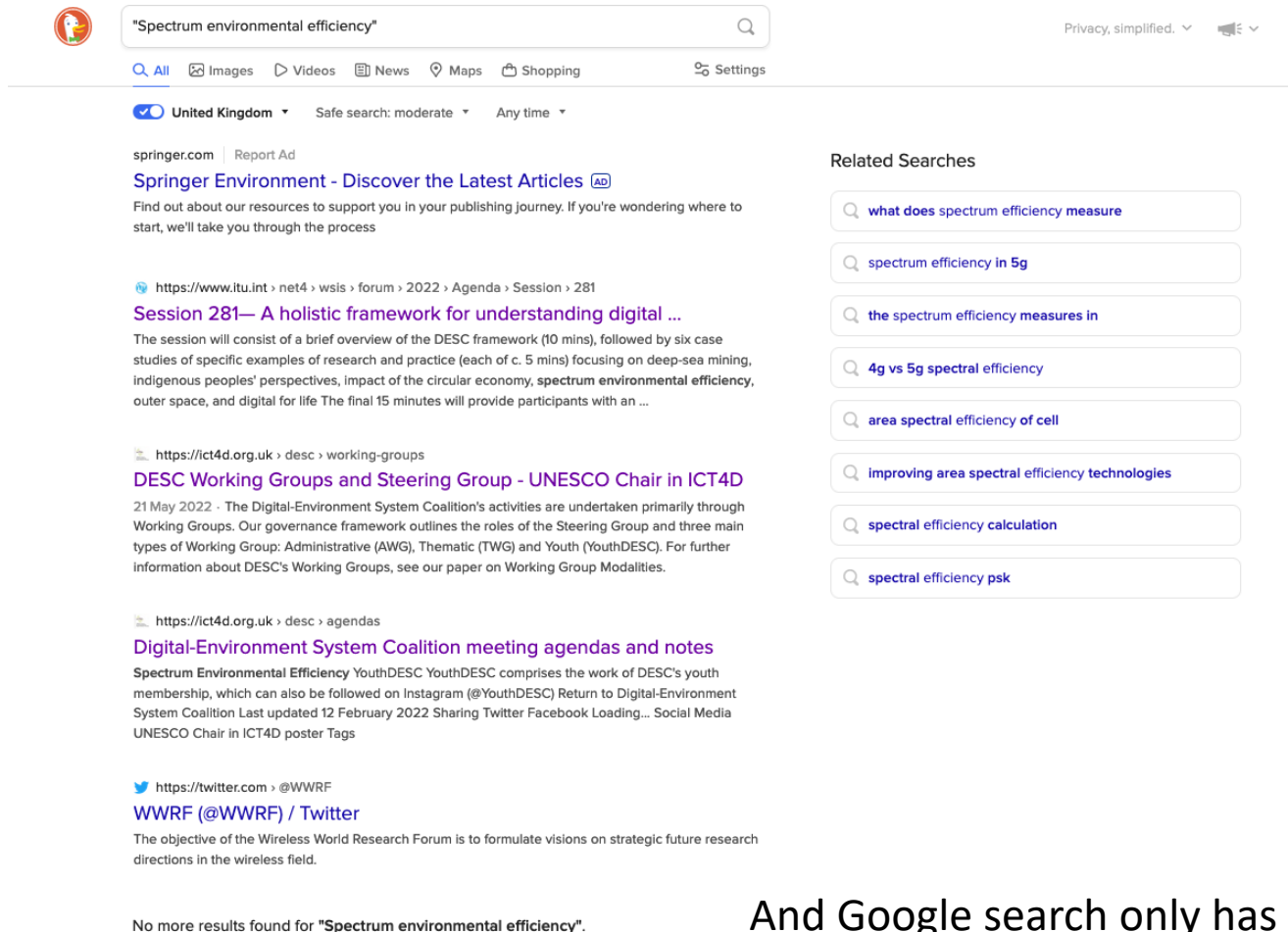
Plenary Session 1: 5/6G and developing countries

Bristol

21<sup>st</sup> June 2022



# Searching for “spectrum environmental efficiency”



The screenshot shows a Google search results page for the query "Spectrum environmental efficiency". The search bar at the top contains the query. Below the search bar, there are navigation options like "All", "Images", "Videos", "News", "Maps", "Shopping", and "Settings". The results are filtered for "United Kingdom".

**springer.com** | Report Ad  
**Springer Environment - Discover the Latest Articles** <sup>AD</sup>  
Find out about our resources to support you in your publishing journey. If you're wondering where to start, we'll take you through the process

<https://www.itu.int/net4/wsis/forum/2022/Agenda/Session/281>  
**Session 281— A holistic framework for understanding digital ...**  
The session will consist of a brief overview of the DESC framework (10 mins), followed by six case studies of specific examples of research and practice (each of c. 5 mins) focusing on deep-sea mining, indigenous peoples' perspectives, impact of the circular economy, spectrum environmental efficiency, outer space, and digital for life The final 15 minutes will provide participants with an ...

<https://ict4d.org.uk/desc/working-groups>  
**DESC Working Groups and Steering Group - UNESCO Chair in ICT4D**  
21 May 2022 - The Digital-Environment System Coalition's activities are undertaken primarily through Working Groups. Our governance framework outlines the roles of the Steering Group and three main types of Working Group: Administrative (AWG), Thematic (TWG) and Youth (YouthDESC). For further information about DESC's Working Groups, see our paper on Working Group Modalities.

<https://ict4d.org.uk/desc/agendas>  
**Digital-Environment System Coalition meeting agendas and notes**  
Spectrum Environmental Efficiency YouthDESC YouthDESC comprises the work of DESC's youth membership, which can also be followed on Instagram (@YouthDESC) Return to Digital-Environment System Coalition Last updated 12 February 2022 Sharing Twitter Facebook Loading... Social Media UNESCO Chair in ICT4D poster Tags

<https://twitter.com/WWRF>  
**WWRF (@WWRF) / Twitter**  
The objective of the Wireless World Research Forum is to formulate visions on strategic future research directions in the wireless field.

No more results found for "Spectrum environmental efficiency".

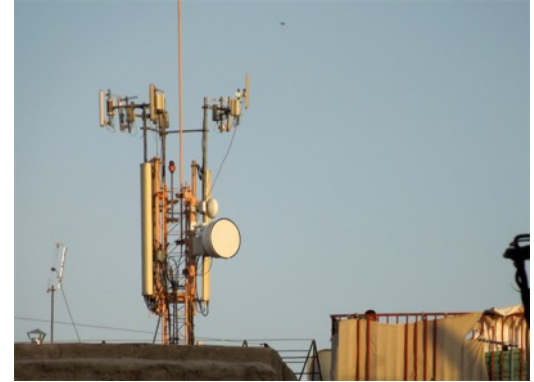
**Related Searches**

- what does spectrum efficiency measure
- spectrum efficiency in 5g
- the spectrum efficiency measures in
- 4g vs 5g spectral efficiency
- area spectral efficiency of cell
- improving area spectral efficiency technologies
- spectral efficiency calculation
- spectral efficiency psk

And Google search only has 7 results found

# WWRF has discussed energy efficiency of spectrum previously

- 5G uses less energy per “data unit” (byte) than 4G
- But the vast number of new sensors means that total energy consumption has increased
- How will next (or evolving) generation spectrum tech and management impact the environment?



WWRF Morocco, 2014

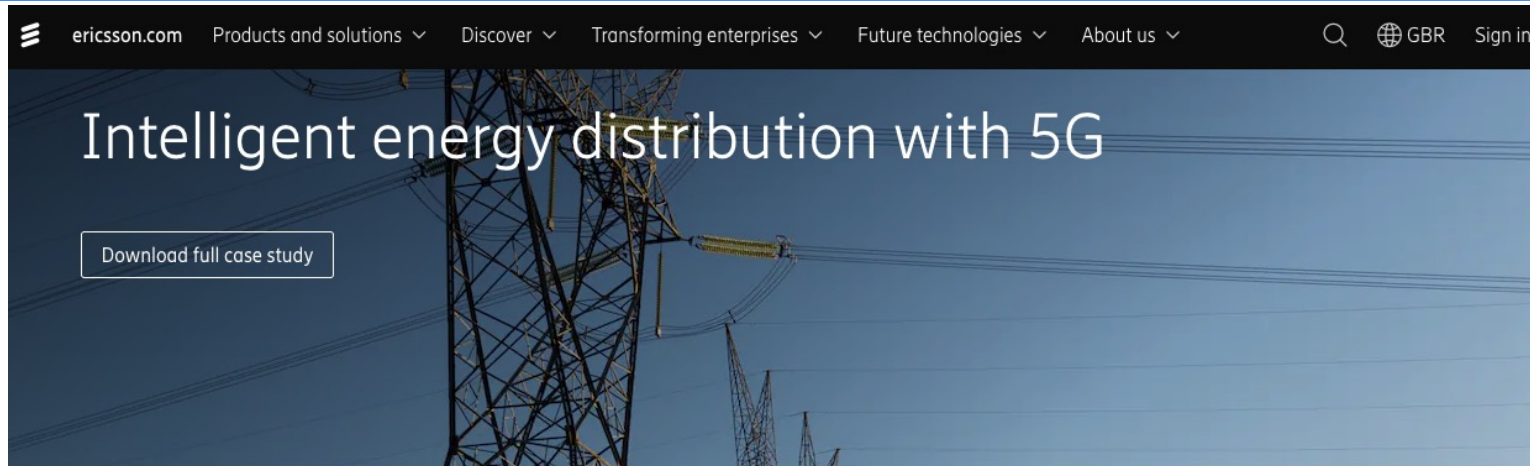
# Growing awareness about spectrum and climate change

Mainly  
positive  
prognosis



The screenshot shows the top of a webpage for techUK. The header includes the techUK logo and navigation links: 'Shaping policy', 'Accelerating innovation', 'Developing markets', 'Who we are', and 'What we'. Below the header is a breadcrumb trail: 'You're here: The UK's technology trade association > What we deliver > Insights > Report: How spectrum policy can help to tackle climate change'. The main content area features the title 'uk spectrum policy forum report' in a large, stylized font. At the bottom of the screenshot, there is a date '21 Oct 2021', a 'Share this page' section with Twitter and LinkedIn icons, and the beginning of the report title: 'Report: How spectrum policy can help to tackle climate change'.

# Tech sector lauding the benefits of 5G



HOME > CASES > 5G IN ENERGY SECTOR FOR NETWORK MODERNIZATION - ERICSSON

## 5G in energy sector for network modernization - Ericsson

We united 13 prominent partners, including utility companies, for the EU's SOGNO (Service Oriented Grid for the Network of the Future) initiative to explore how modernization and digitalization can help to create the power networks of the future.

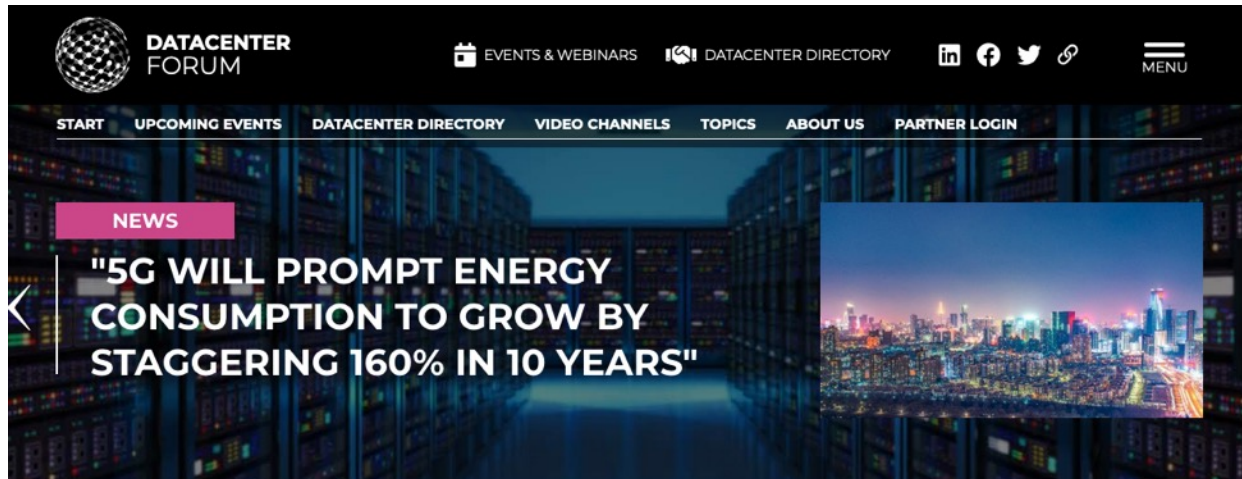
CASE | 5G Networks Mission Critical Communications

#5GBusiness #ESB #CEZ

<https://www.ericsson.com/en/cases/2020/sogno-initiative-for-power-network-modernization>



# Yet very considerable increases in energy use



The screenshot shows the Datacenter Forum website. The header includes the Datacenter Forum logo, navigation links for 'EVENTS & WEBINARS', 'DATACENTER DIRECTORY', and social media icons for LinkedIn, Facebook, Twitter, and YouTube. A main navigation bar contains 'START', 'UPCOMING EVENTS', 'DATACENTER DIRECTORY', 'VIDEO CHANNELS', 'TOPICS', 'ABOUT US', and 'PARTNER LOGIN'. The main content area features a large image of server racks with a city skyline at night overlaid. A pink 'NEWS' tag is visible on the left. The headline reads: "5G WILL PROMPT ENERGY CONSUMPTION TO GROW BY STAGGERING 160% IN 10 YEARS".

Datacenter Forum

updated: 12-10-2021 | 12:48



The massive projected increase in power needs of the world's mobile technology – a more than doubling by 2030 – underscores a call for an increasing role of renewable energy in mobile. According to a joint study released today by InterDigital, a mobile and video technology research and development company, and ABI Research, the 5G ecosystem will see a 160% increase in power requirements by 2030, reaching the expected equivalent of all the energy consumption of Sweden.

<https://www.datacenter-forum.com/datacenter-forum/5g-will-prompt-energy-consumption-to-grow-by-staggering-160-in-10-years>

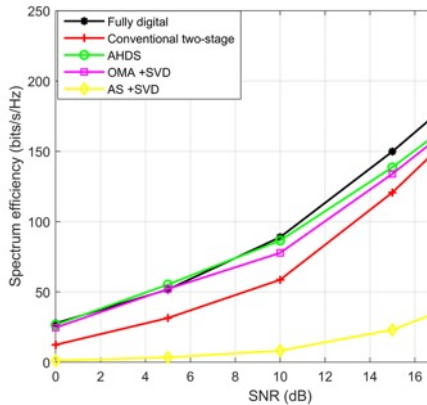
# Digital tech has been developed in a cheap energy environment



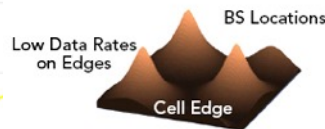
[https://en.wikipedia.org/wiki/Coal-fired\\_power\\_station](https://en.wikipedia.org/wiki/Coal-fired_power_station)

It would surely have been designed very differently if energy had been expensive over the last 20 years - imagine use of spectrum in a high-cost energy context

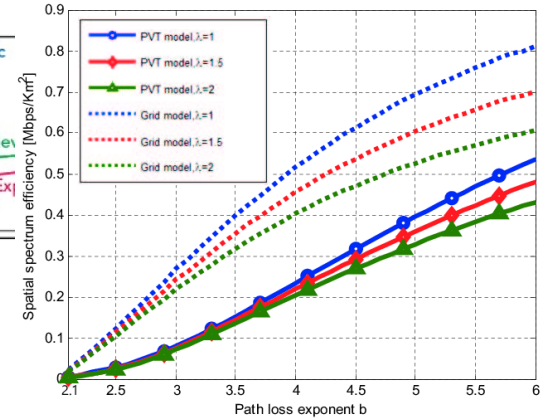
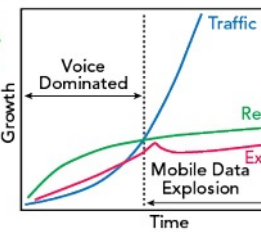
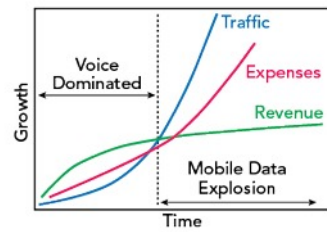
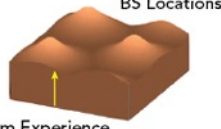
# Much previous work on spectrum efficiency



Increased Capacity, Increased Expenses



Optimal Network



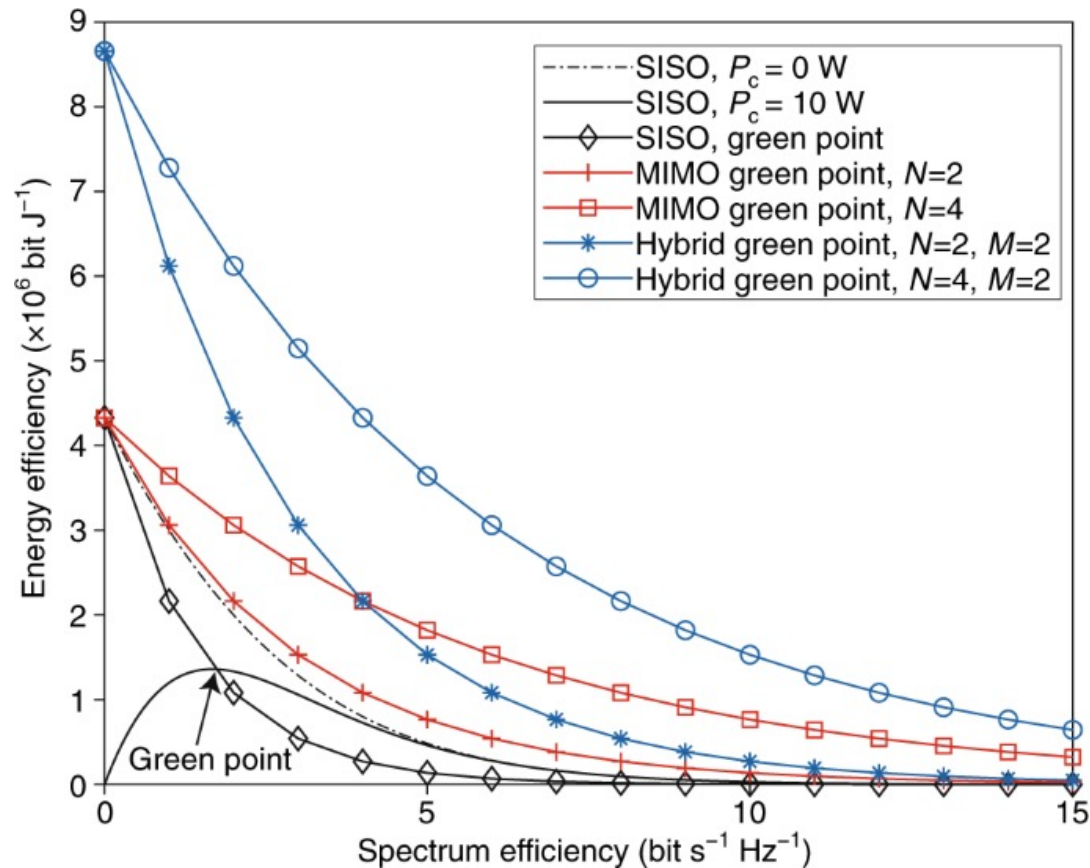
[https://www.researchgate.net/figure/Spatial-spectrum-efficiency-with-respect-to-the-path-loss-exponent-b-considering\\_fig15\\_271218638](https://www.researchgate.net/figure/Spatial-spectrum-efficiency-with-respect-to-the-path-loss-exponent-b-considering_fig15_271218638)

<https://www.microwavejournal.com/articles/print/33436-pillars-of-5g-spectral-energy-efficiency>

[https://www.researchgate.net/figure/Spatial-spectrum-efficiency-with-respect-to-the-path-loss-exponent-b-considering\\_fig15\\_271218638](https://www.researchgate.net/figure/Spatial-spectrum-efficiency-with-respect-to-the-path-loss-exponent-b-considering_fig15_271218638)



# And ongoing research on energy efficiency



Source: I, CL., Han, S. & Bian, S. (2020)



<https://climate.nasa.gov/solutions/adaptation-mitigation/>

**But “climate change”  
and the environment  
are fundamentally  
different concepts**

**Need for new *holistic* ways to evaluate both positive and negative *environmental* impacts of wireless technologies...**



<https://www.bbc.co.uk/news/technology-56805844>

And design better for future impact on the environment



**... “for future mobile networks”, and “impact of connecting more and more devices” \***

**Especially in a holographic future**

\* Dimitra Simeonodou’s opening address

# Current evidence on spectrum environmental efficiency

- No comprehensive and holistic framework for assessing spectrum environmental efficiency
  - The environment impact of different spectrum implementations and management
  - Not just energy (and carbon) but on all aspects of the physical environment
- Idea emerged from discussions with Joanne Wilson (ITU) and Knud Erik Skouby (WWRF/Aalborg University)
- Conceptually, the wireless spectrum itself can be understood as part of the physical environment
  - In which case, the focus needs to be on how different usages have wider environmental impact
- 5G widely seen as being more energy efficient
  - But total increases in traffic mean that 5G systems require more energy
  - And what about wider environmental impacts of human design, management and usage of the wireless spectrum?
  - And how can next generations minimise environmental harms?



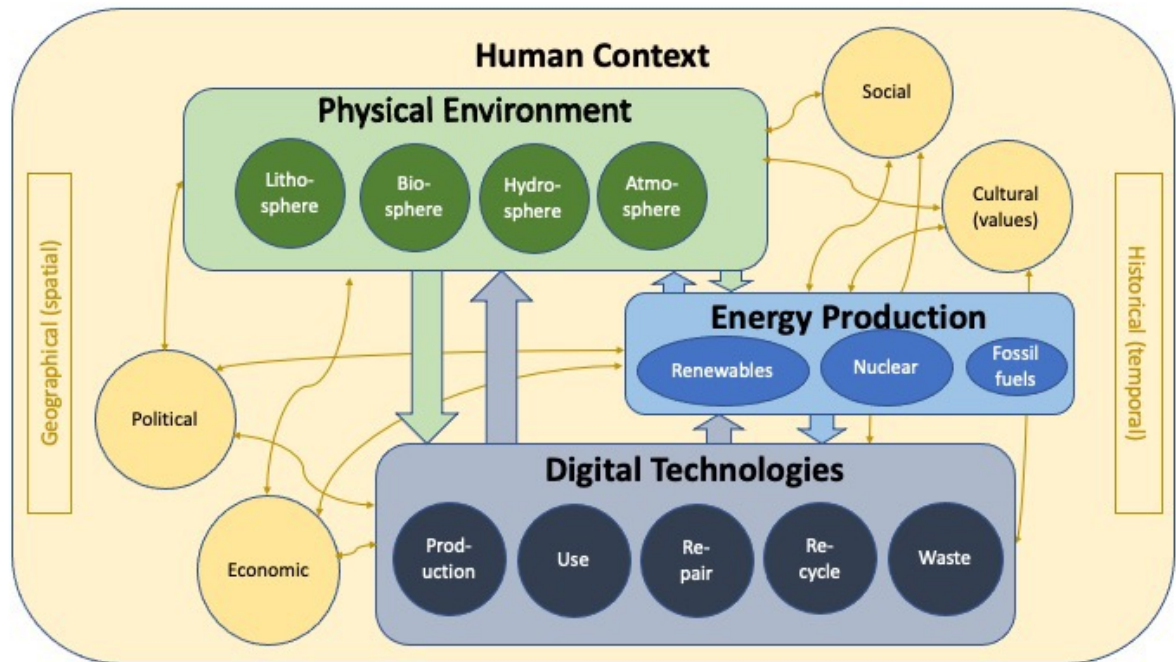
# The Digital Environment System Coalition (DESC)



A multi-sector coalition of researchers, companies, UN agencies, civil society, and governments



# Crafting a new more holistic systemic framework – exploring the positives and negatives within this system



WIRELESS WORLD  
RESEARCH FORUM

is a DESC partner



# Practical evaluation: what has been published and what does it suggest?

	A	B	C	D	E	F	G	H	L	M	N	O	P	Q	R	S
1	<b>Basic structure for review of research on</b>		<b>Production</b>			<b>Use</b>			<b>Repair</b>		<b>Recycle</b>			<b>Waste</b>		
2	<b>impact of any digital tech on the environment</b>															
3																
4																
5	<b>Physical Environment</b>															
6		Lithosphere														
7		Biosphere														
8		Hydrosphere														
9		Atmosphere														
10																
11																
12																
13																
14	<b>Energy production</b>															
15		Renewables														
16		Nuclear														
17		Fossil														
18																
19																
20																
21	<b>Human context</b>															
22		Cultural														
23		Social														
24		Political														
25		Economic														
26																
27																
28																
29																
30																
31	<b>Spatial implications (cross cutting)</b>															
32																
33																
34	<b>Temporal context (cross cutting)</b>															
35																

# Towards a research agenda

- Always taking environmental considerations (not just climate and energy) into our research considerations
- What are environmental implications of using different parts of the spectrum?
- How do different masts/antennae impact the environment?
  - New ways of assessing landscape impact
- Environmental implications of sensor networks...
- Recommendations for good practices by telecom/wireless companies – and regulators
- Helping develop a toolkit for UN [Partner2Connect](#) digital coalition
- Links with DESC working group on satellites and outer space (with UNOOSA involvement)





# Example of UNOOSA work

## Dark & Quiet Skies for Science & Society

### Threats

- ❑ Astronomical observation and research (deep space navigation and exploration, defend the Earth from asteroids, study origins of the Earth)
- ❑ Bio-environment including human health
- ❑ Ability of our citizens to view a pristine, starry sky

**Recommendations** are being developed with the International Astronomical Union to:

- ❑ propose mitigation measures at local level to protect the sky
- ❑ gather the space community at international level to discuss the impact of satellite constellations in LEO

Care has been taken to propose recommendations that are both technically and economically feasible and do not affect the main purpose behind the source of interference (e.g., space-based network connectivity which helps bring internet to the underserved and hard-to-reach regions).

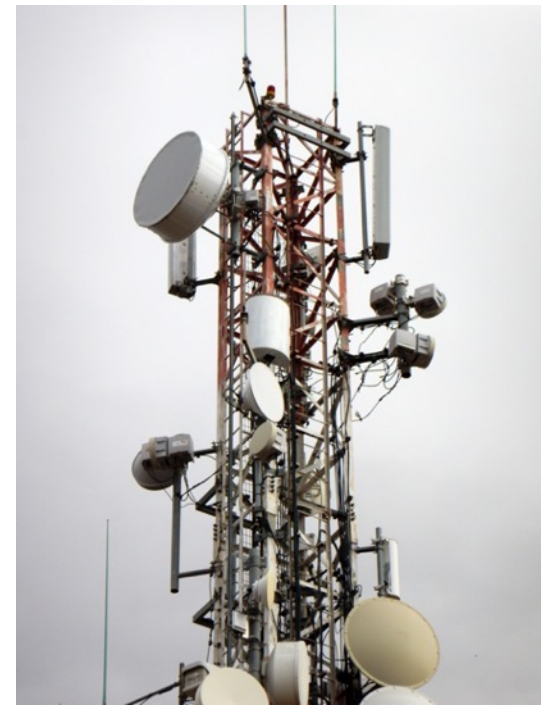


# Indigenous environmental knowledges

- Much “international development” is
  - Top-down
    - International agencies, bilateral donors, scientists...
  - Assumes superiority of “Western” knowledge and science
  - Imposes “our” views on a less-developed “other”
- Importance of indigenous environmental knowledges
  - New perspectives and insights
  - Solutions that are relevant to “their” needs
  - Vital for ensuring “sustainability”



# If of interest, do get involved...



- Knud Erik Skouby is leading DESC's Working Group on spectrum environmental efficiency
- Become an individual member of DESC
- Or a partner (especially eager to engage private sector)

<http://desc.global>

# Some useful references

- I, CL., Han, S. & Bian, S. (2020) “Energy-efficient 5G for a greener future”, *Nat Electron* **3**, 182–184  
<https://doi.org/10.1038/s41928-020-0404-1>
- Cui, C., Yang, D. & Jin, S. (2021). Robust Spectrum-Energy Efficiency for Green Cognitive Communications. *Mobile Netw Appl* **26**, 1217–1224 <https://doi.org/10.1007/s11036-019-01347-y>
- Gurjar, D. S., Nguyen H. H. and Tuan, H. D. (2019) "Wireless Information and Power Transfer for IoT Applications in Overlay Cognitive Radio Networks," in *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 3257-3270, April, <https://doi.org/10.1109/JIOT.2018.2882207>
- Ibhaze, A.E., Imoize, A.L., and Okoyeigbo, O. (2022) “A Brief Overview of Energy Efficiency Resources in Emerging Wireless Communication Systems”, *Telecom*, 3, 281–300, <https://doi.org/10.3390/telecom3020016>
- Kim, S. W. (2019) "Simultaneous Spectrum Sensing and Energy Harvesting," in *IEEE Transactions on Wireless Communications*, vol. 18, no. 2, pp. 769-779, Feb., <https://doi.org/10.1109/TWC.2018.2879655> .
- Park, H. and Hwang, T. (2016) "Energy-Efficient Power Control of Cognitive Femto Users for 5G Communications," in *IEEE Journal on Selected Areas in Communications*, vol. 34, no. 4, pp. 772-785, April, <https://doi.org/10.1109/JSAC.2016.2544601>
- Rowell, C. (2020) “Pillars of 5G: Spectral and Energy Efficiency”, *Microwave Journal*,  
<https://www.microwavejournal.com/articles/print/33436-pillars-of-5g-spectral-energy-efficiency>