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RELATIONSHIP BETWEEN SMR AND PLANETARY BOUNDARIES

A mitigation strategy for the global environmental crisis

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Agenda

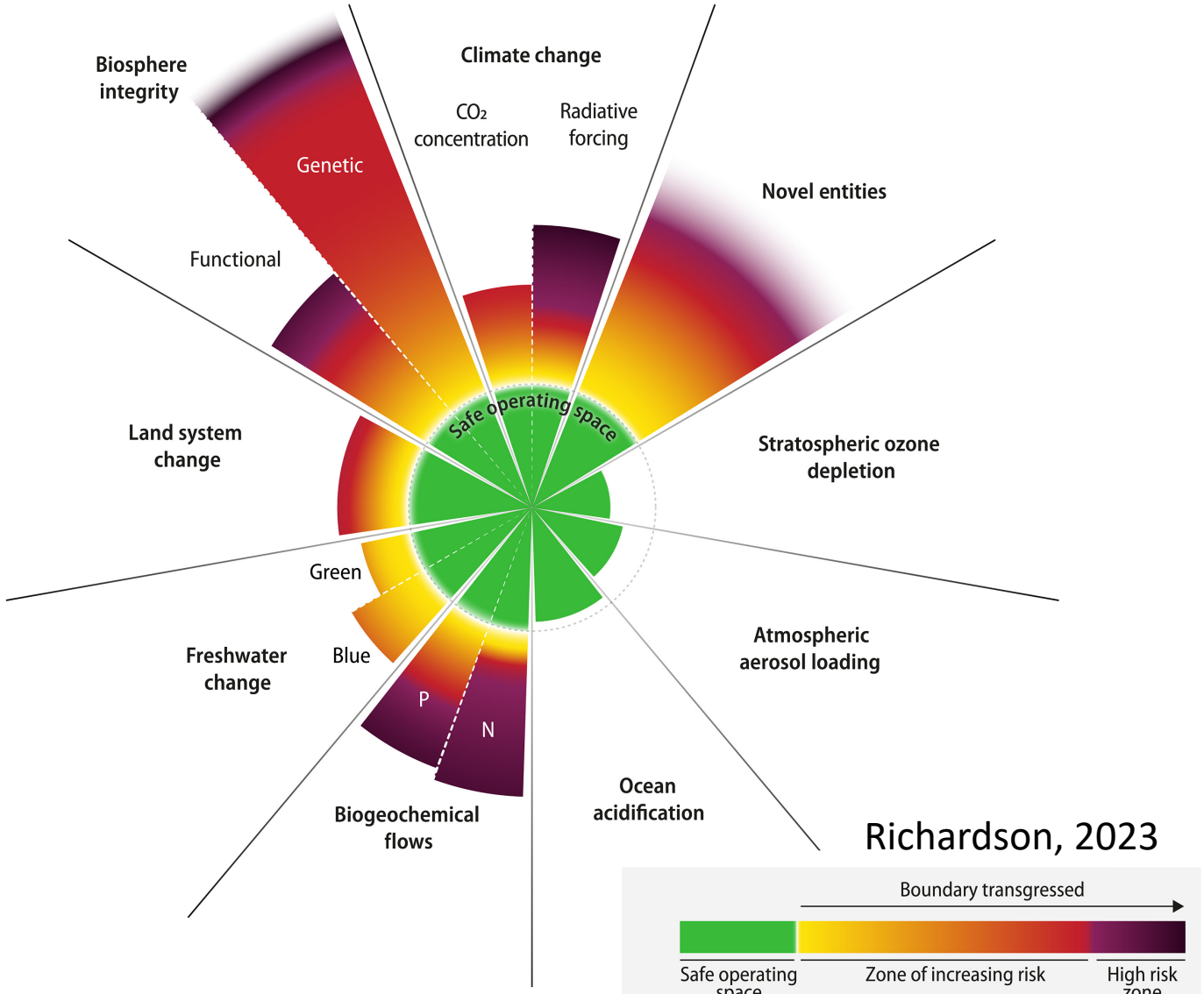
1. Introduction
2. Methodology
3. Results
4. Conclusions
5. Discussion and future research

Relationship between SMR and Planetary Boundaries

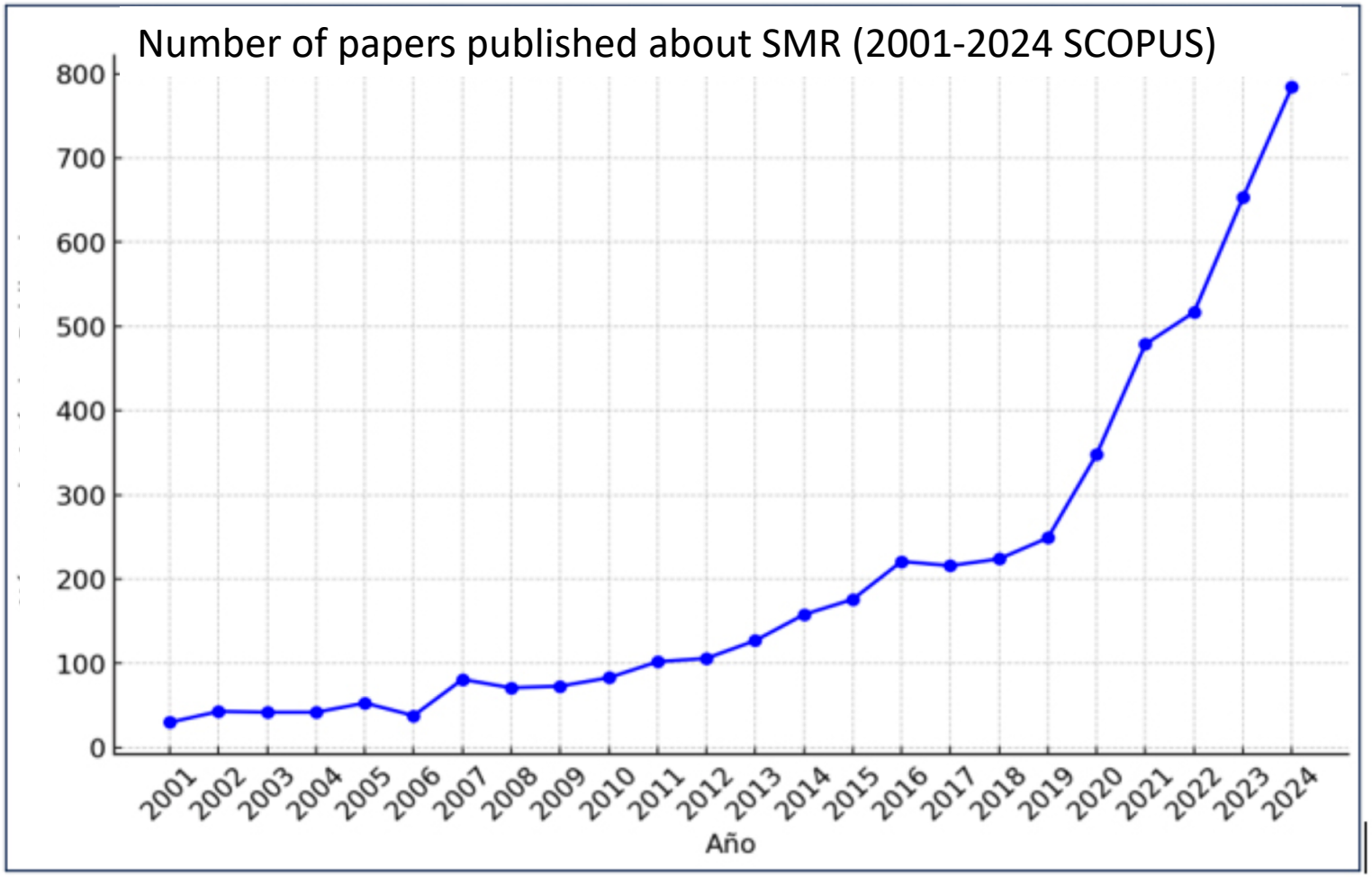
No author associated with this article has disclosed any potential or relevant conflict that could be perceived as an **imminent conflict** with this research work.

Relationship between SMR and Planetary Boundaries

Planetary boundaries



Relationship between SMR and Planetary Boundaries



Research gap

Using the terms “SMR” and “nuclear” in the SCOPUS database, as of July 2024, with a publication limit since 2001, **4916 records were found**, of which 581 correspond to book chapters, 171 to encyclopedia entries and the remaining to research article publications.

Research gap

We based our research on peer-reviewed scientific literature using the SCOPUS, ScienceDirect, and ARIS databases from the IAEA.

In the case of land use intensity, no specific values were found for SMRs, only for large reactors (LR). Therefore, a mathematical model was selected to calculate the land use intensity, considering the LCA and the data on operational area described in the design datasheets included in the ARIS database.

Methodology

Calculation of Total Land Use Intensity of Energy ($LUIE_t$)

$$\mathrm{LUIE}_{\mathrm{direct}} = \frac{A_{direct}}{Energy}\left[\frac{ha * y}{TWh}\right]$$

Formula 1: Direct land-use intensity of energy

$$\mathrm{LUIE}_{\mathrm{indirect}} = \frac{A_{indirect}}{Energy}\left[\frac{ha * y}{TWh}\right]$$

Formula 2: Indirect land-use intensity of energy

Methodology

Calculation of Total Land Use Intensity of Energy ($LUIE_t$)

$$\mathrm{LUIE}_{\mathrm{total}} = \frac{A_{indirect} + A_{direct}}{Energy} \left[\frac{ha * y}{TWh}\right]$$

Formula 3: Total land-use intensity of energy

Methodology

Calculation of Total Land Use Intensity of Energy ($LUIE_t$)

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Formula 1: Direct land-use intensity of energy

$$\text{LUIE}_{\text{indirect}} = \frac{A_{indirect}}{Energy} \left[\frac{ha * y}{TWh}\right]$$

Formula 2: Indirect land-use intensity of energy

Methodology

Calculation of Total Land Use Intensity of Energy ($LUIE_t$)

To estimate **the indirect area** related to the extraction and processing of uranium, a value of **0.08 ha/TWh/y** was taken, and for the indirect area associated with waste disposal, a value of **0.012 to 2.9 ha/TWh/y**

Methodology

Calculation of Total Land Use Intensity of Energy ($LUIE_t$)

In the case of LRs, several authors add the value related to the exclusion zones around the two main nuclear energy accidents at Chernobyl in Ukraine (260,000 ha) and Fukushima in Japan (63,000 ha). **For the case of SMRs, this was not included** because it is a different nuclear technology. If included, they would add to the calculation **3.9 ha/TWh/y**.

Relationship between SMR and Planetary Boundaries

Results

DIRECT LUIE ACCORDING SMR TYPE

SMR Type	ha/TWh/y $_{CF\ 95\%}$	ha/TWh/y $_{CF80.2\%}$
Land based Water-Cooled Reactor SMR	5	5
Marine based Water-Cooled Reactor SMR	8	10
Fast Neutron Spectrum SMR	4	4
Hight Temperature Gas Cooled SMR	10	10
Molten Salt SMR	2	3
Microreactors	7	9
Mean Direct LUIE	6	7

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Results

Using the **lower limit** of the waste area and direct LIU, the result obtained is **6.092 ha/TWh/y**; using the upper limits of the indirect waste area and the direct area, the value **reaches 9.98 ha/TWh/y**, hence a mean for this range **of 8.036 ha/TWh/y**.

Relationship between SMR and Planetary Boundaries

Results

TOTAL LUIE MEAN BY ENERGY SOURCE

Source of energy	LUIE total (ha/TWh/y) Mean
Hydroelectric	15000
Ground-mounted PV	2100
Natural gas	410
Wind	170
Nuclear LR	15
SMR	8

Results

EMISSION FACTOR BY SOURCE

Source of energy	Emission factor (gCO_2eq/kWh)
SMR NuScale	4,6
SMR Westinghouse iPWR	5,9 - 13,2
Large reactors	5,13

Conclusions

The review of the literature and the data obtained allow us to conclude that SMRs can be a very relevant contribution to the global environmental crisis. The fact that they have a low land use intensity makes them highly efficient in this respect.

They are a source of low-emission generation and after reviewing the obtained values, we can affirm that their performance in this regard is very similar to that of power reactors.

The cogeneration associated with SMRs enables efficient desalination of water, and the implementation of such projects will favor the availability of fresh water.

Future research

It is necessary to develop more research studies that evaluate the LCA of different SMR designs. In the present work, only two designs were reviewed, which are PWRs, and it is necessary to verify if other technologies have different environmental impacts

Keep in touch

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