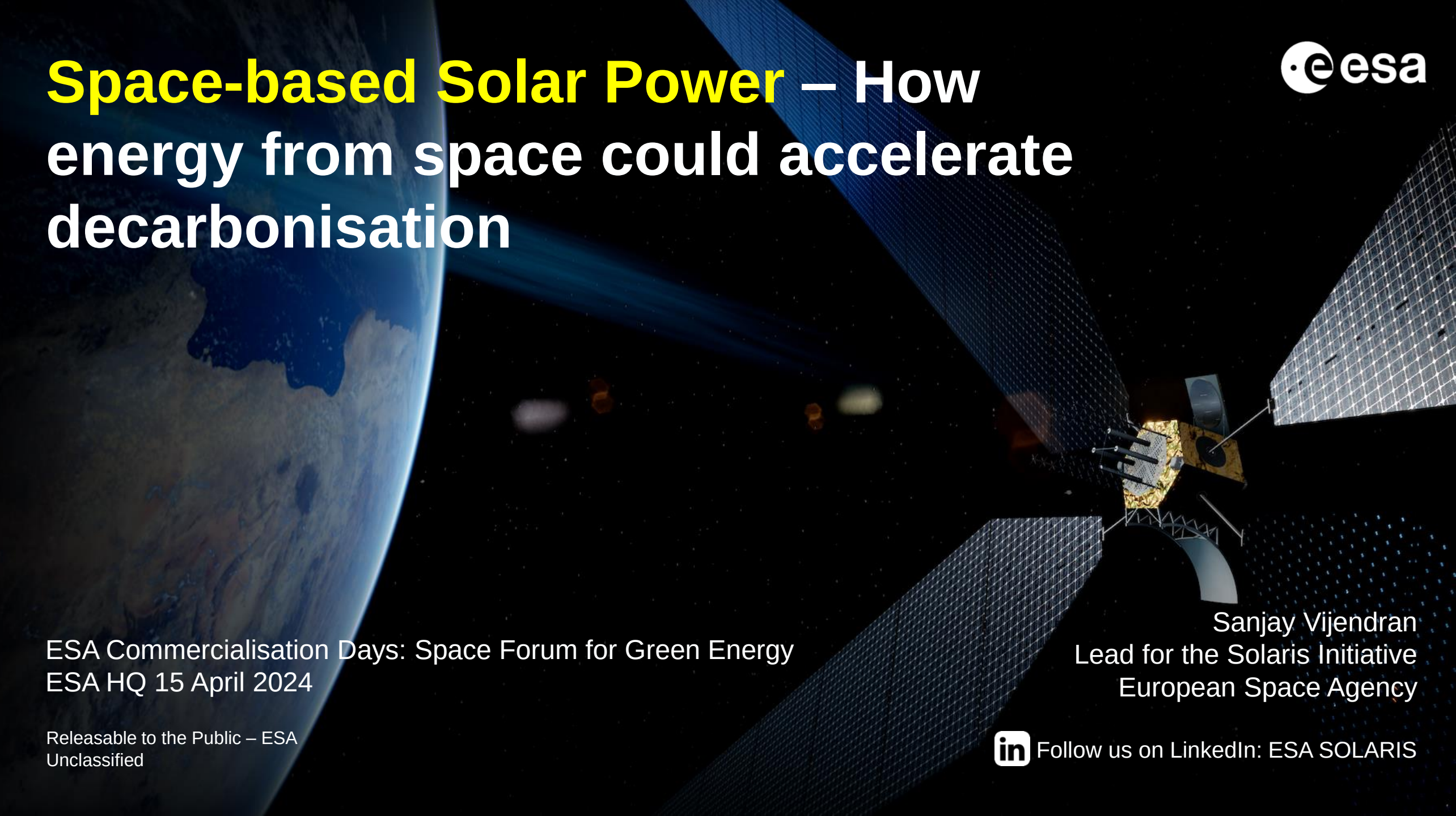
Space-based Solar Power – How energy from space could accelerate decarbonisation



ESA Commercialisation Days: Space Forum for Green Energy
ESA HQ 15 April 2024

Sanjay Vijendran
Lead for the Solaris Initiative
European Space Agency

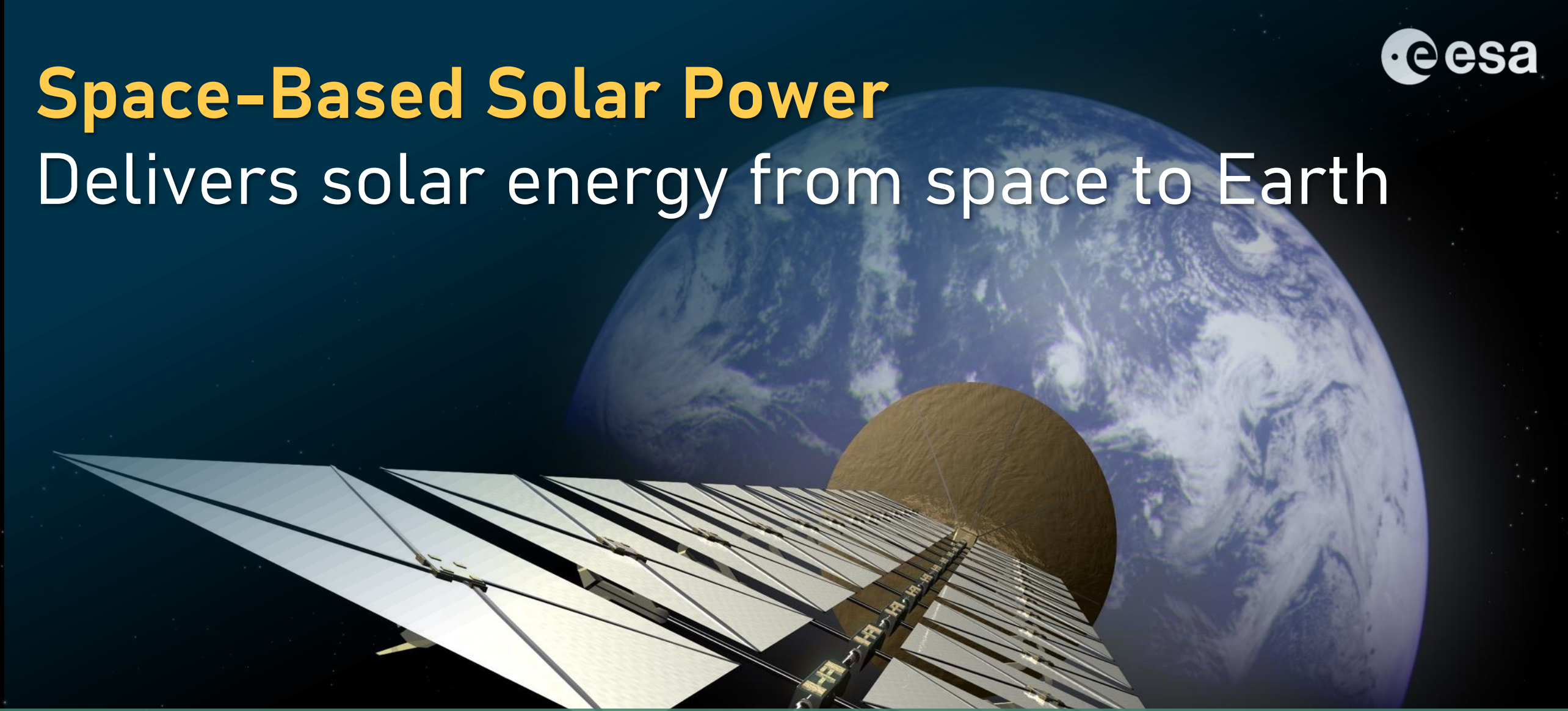
Follow us on LinkedIn: ESA SOLARIS

Existing energy options have **major challenges**

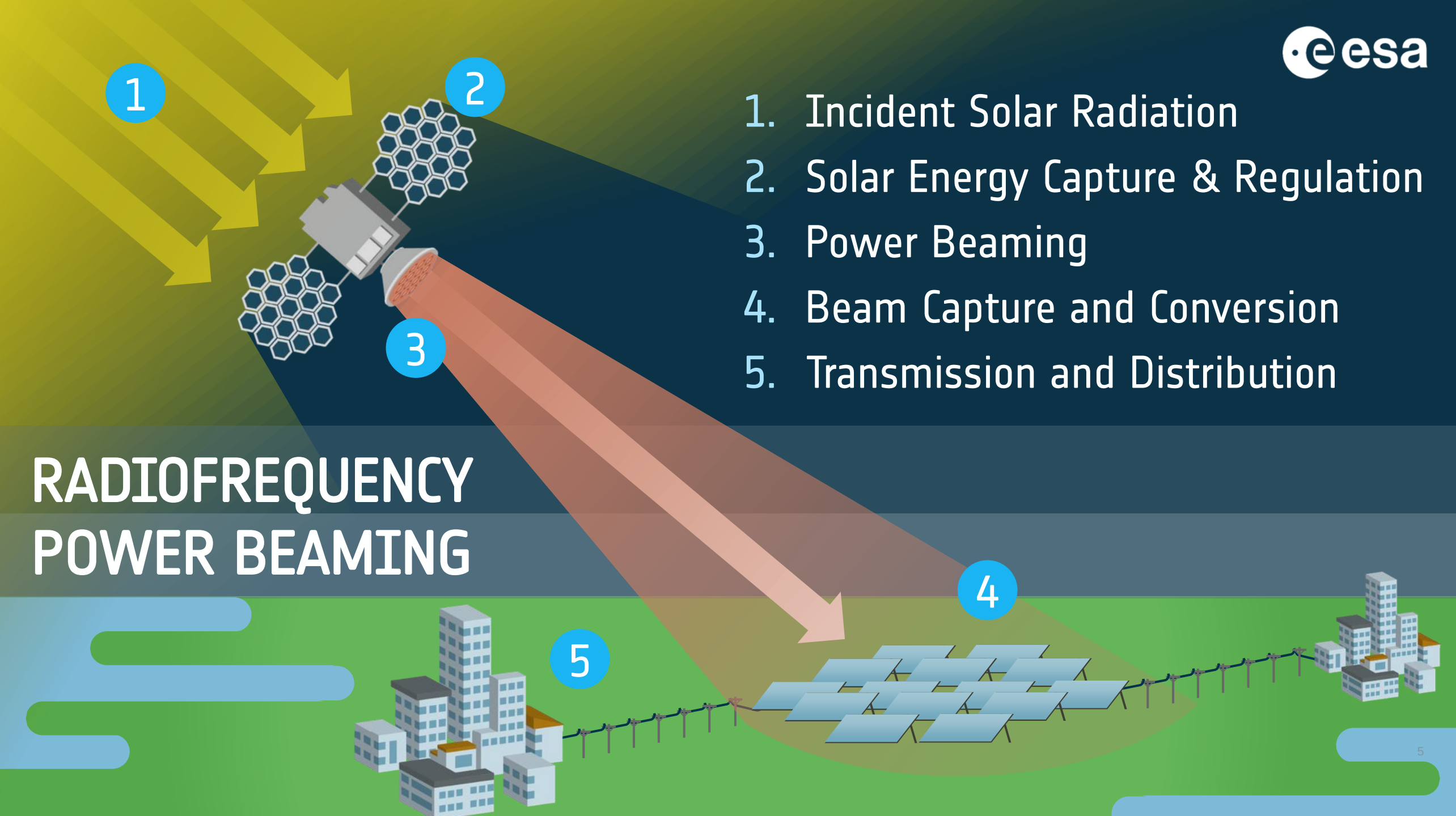
Scalability? **Availability?** **Land Use?**

Space-Based Solar Power

Delivers solar energy from space to Earth



Green, 24/7, affordable, scalable, secure and **available to everyone**


1
2
3
4
5
1. Incident Solar Radiation
2. Solar Energy Capture & Regulation
3. Power Beaming
4. Beam Capture and Conversion
5. Transmission and Distribution
RADIOFREQUENCY
POWER BEAMING

Ground receiver for radiofrequency power reception

~130 km²

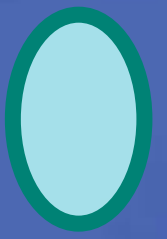
~600 MW

Nameplate capacity

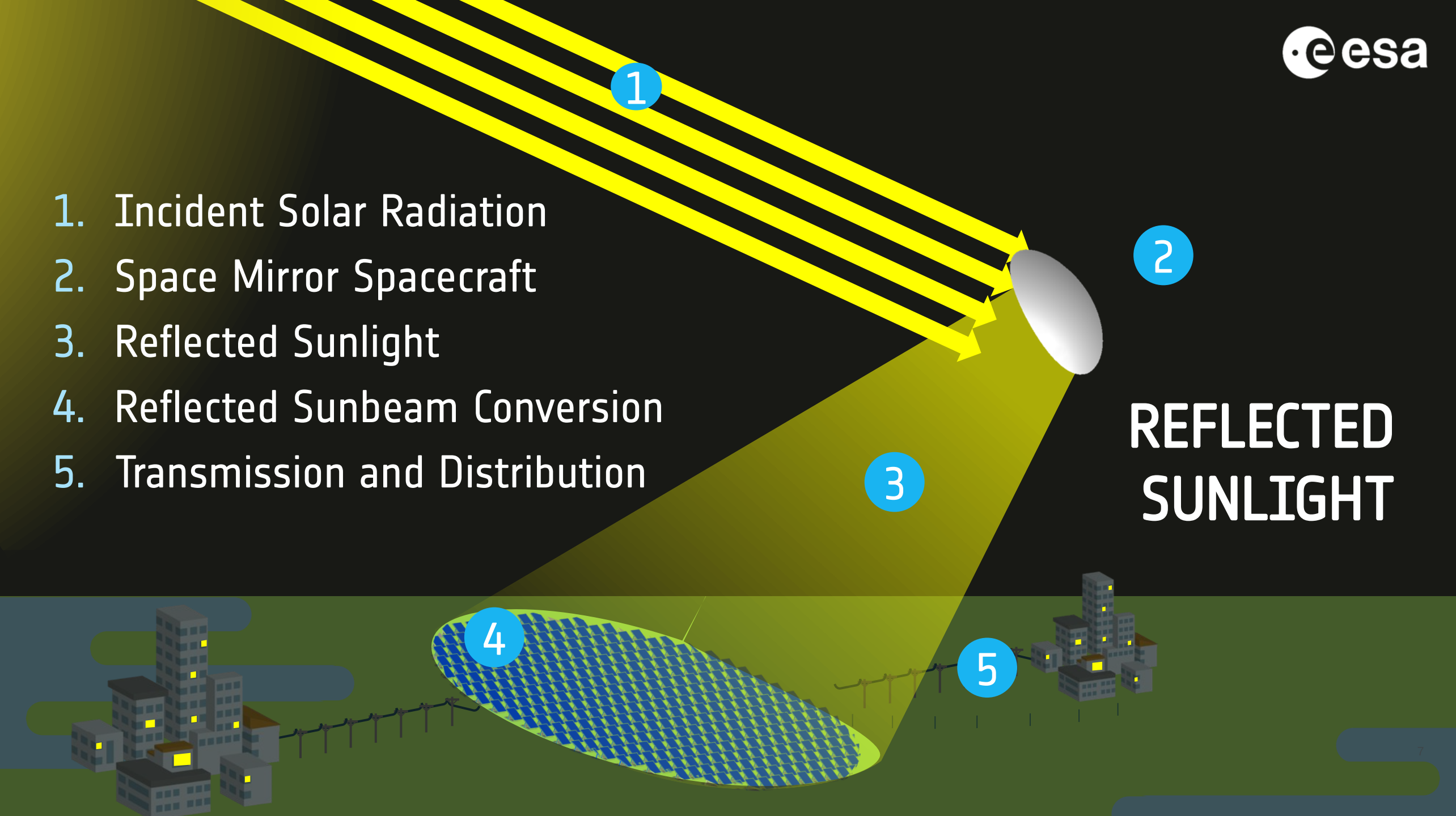
~75 km²

~2 GW

Continuous



SBSP Ground Rectenna


1. Incident Solar Radiation
2. Space Mirror Spacecraft
3. Reflected Sunlight
4. Reflected Sunbeam Conversion
5. Transmission and Distribution
1
2
3
4
5
REFLECTED SUNLIGHT

SOLAR FARMS RECEIVING REFLECTED SUNLIGHT

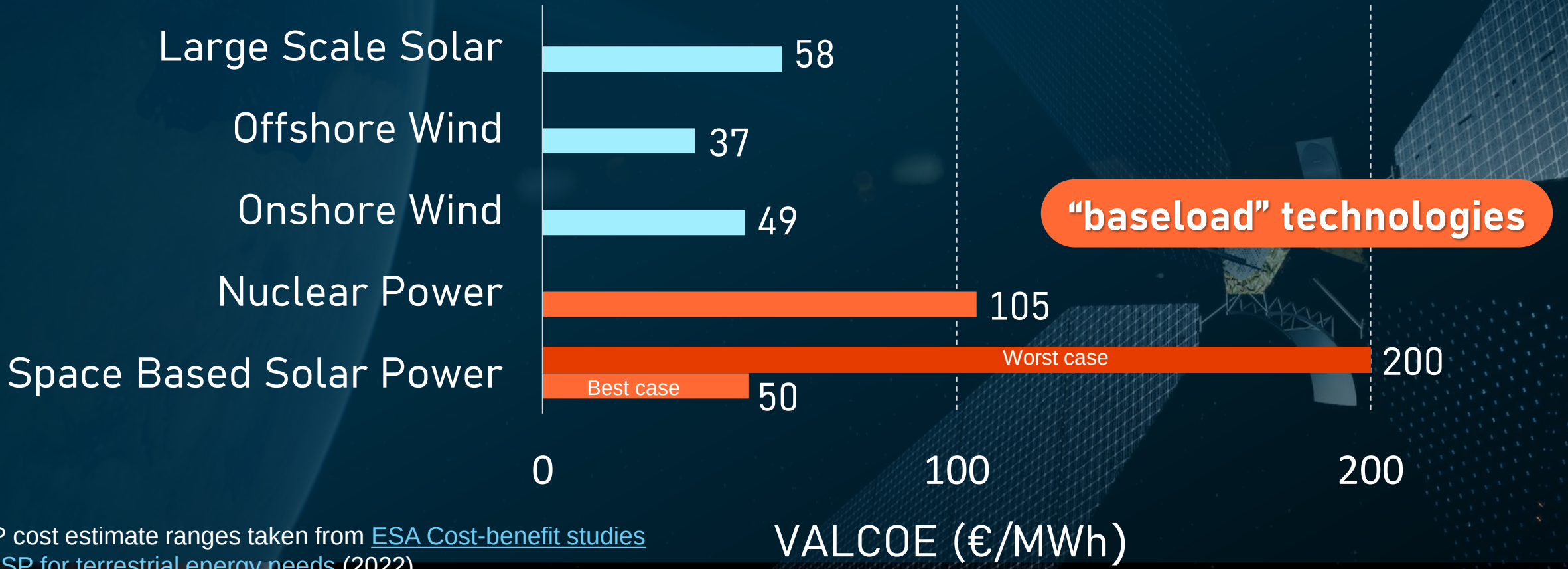
Up to 2 hours extra midday sun at dawn and dusk => ~60% additional electricity generation / year

ARTHUR D LITTLE

Artist's Concep

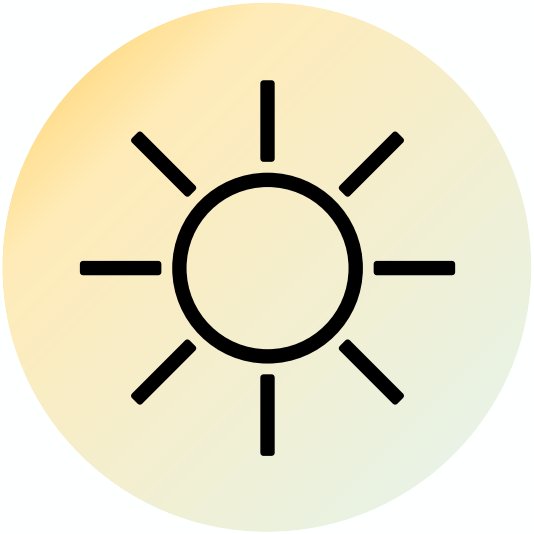
How much will the electricity cost?

Projected Value adjusted Cost of Energy (VALCOE) in 2050 for Low Carbon Energy Generation (10th of a Kind SPS)

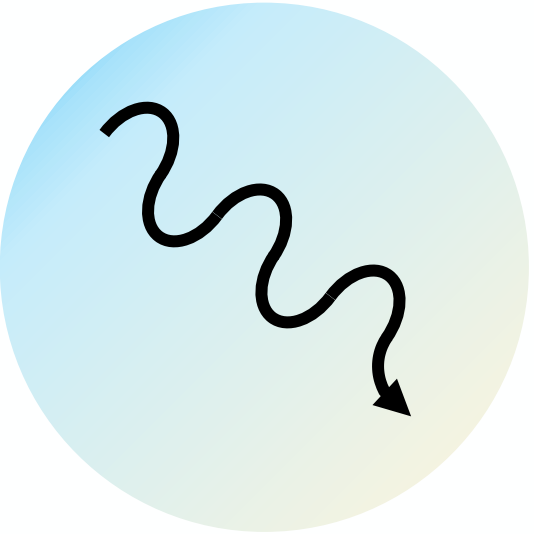


SBSP cost estimate ranges taken from ESA Cost-benefit studies of SBSP for terrestrial energy needs (2022)

Is SBSP safe?



Power density (10-230 W/m^2) on ground is ¼ that of full summer sun



Wavelength (5-15 cm) of received beam is non-ionizing (similar frequency to wi-fi and cell phones)

Encrypted retrodirective pilot beam used as off-switch for off-rectenna pointing

There are many risks….

Political

Technological

Economic

Legal

Social

Environmental and safety

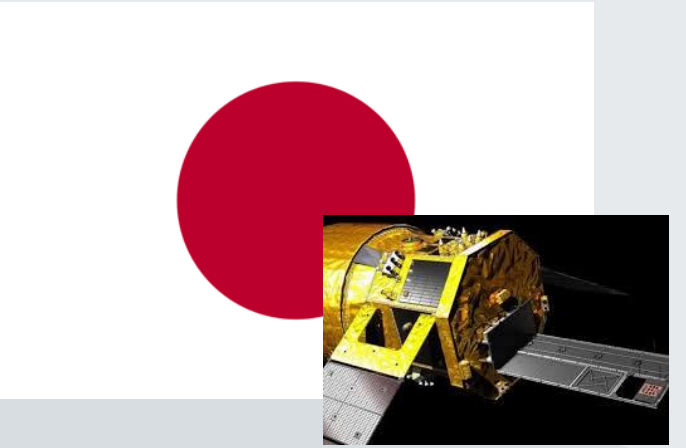
[3]

….but no showstoppers.

SBSP is already being developed around the world

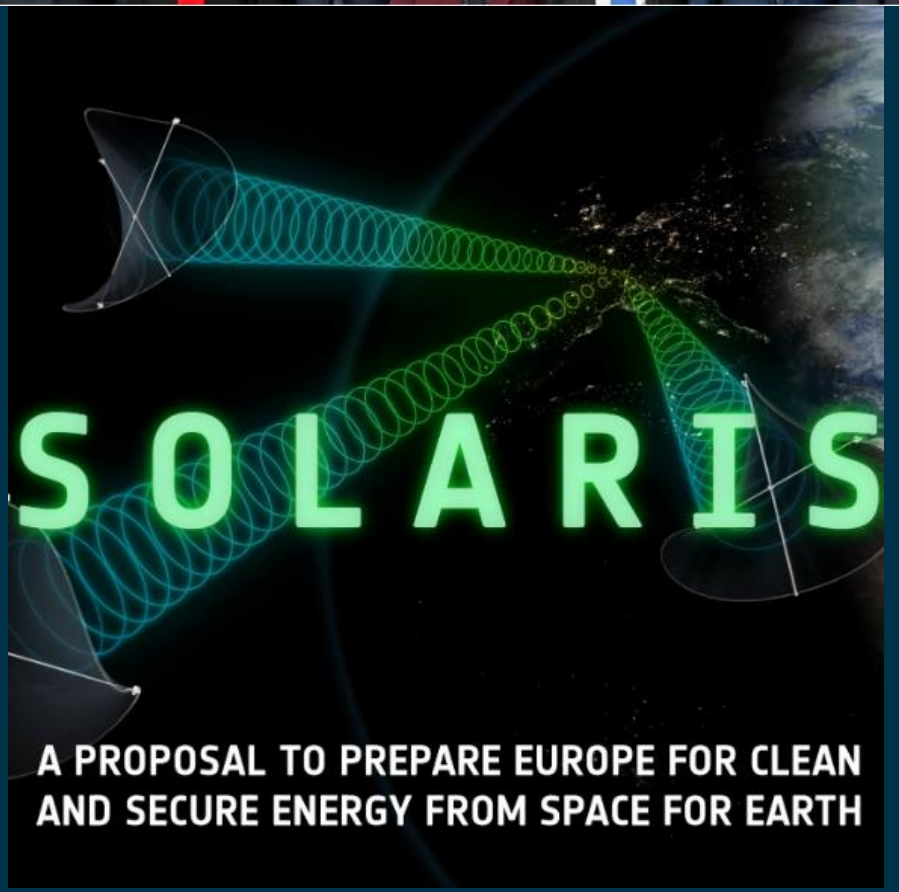
- US Navy did space tests (2020) and Air Force planning space-ground tests in 2025
- 100 M$ private donation to Caltech. Techno demos launched in Jan 2023

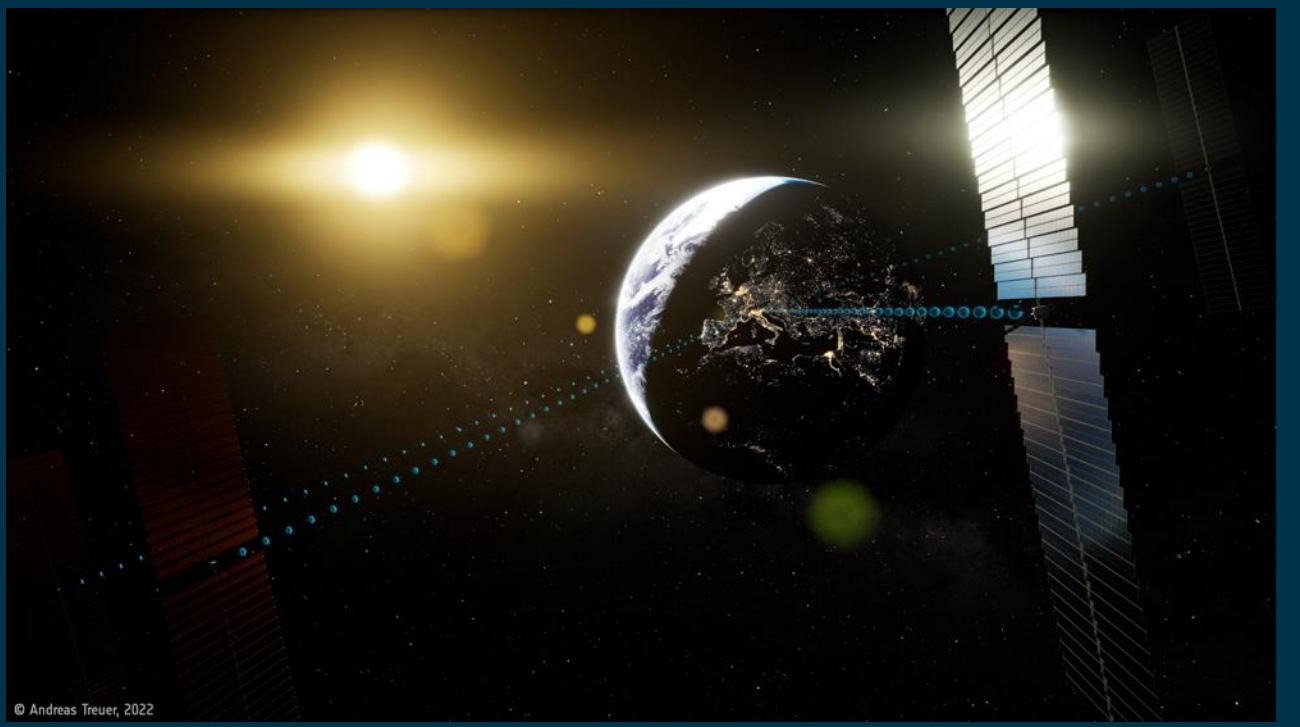
- Space-ground demo planned for 2028
- MW-level early 2030's
- GW commercial plant by 2050
- SBSP ground station & test facilities already being developed



- Long-term technology programme in JAXA (Basic Space Policy)
- In-space demo mission planned for 2025 launch


esa
AMBITION
Council Meeting at Ministerial Level
Paris, 22-23 November 2022
esa


SOLARIS
A PROPOSAL TO PREPARE EUROPE FOR CLEAN
AND SECURE ENERGY FROM SPACE FOR EARTH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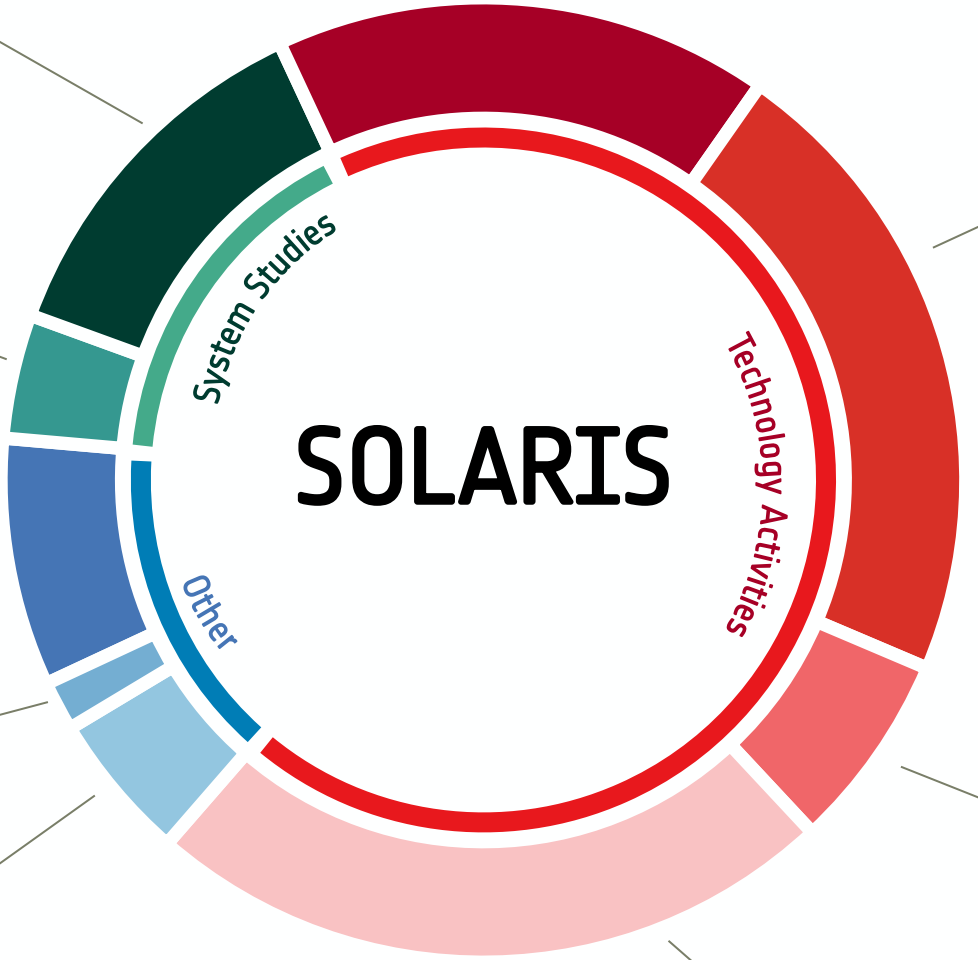


Prep. Studies for SPS Demonstrator (Phases 0/A/B1)

Prep. Studies for Commercial-Scale SPS (Phase 0)

Ground / Aerial Power Beaming Demonstration

Stakeholder Engagement, Regulation and Outreach

Environmental, Health & Safety Studies

Highly mass and cost-efficient photovoltaic systems

Highly efficient RF generation and beam forming

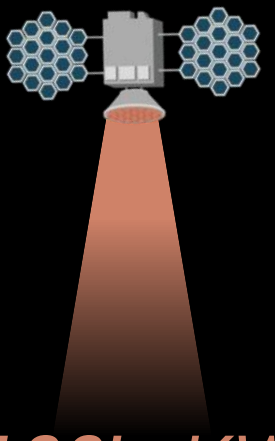
High power management and distribution

Large structure deployment, in-space manufacturing, robotic assembly

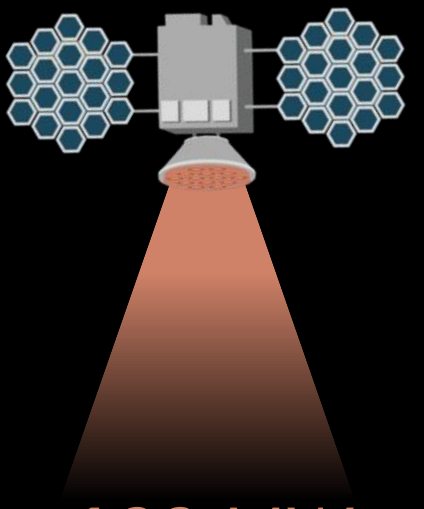
Notional European SBSP Roadmap

Future phases still to be confirmed

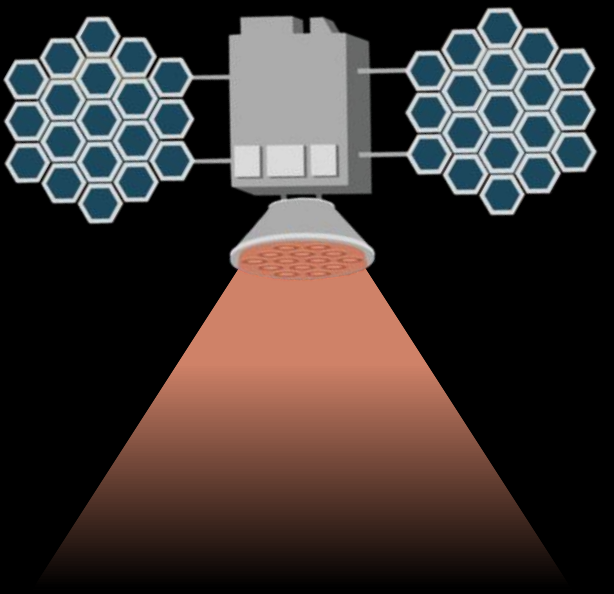
Ground Demos



100's KW



100 MW



Multi-GW

2023-2025

SOLARIS R&D initiative

2026-2030

Sub-Scale Space-Based Demonstrator

2031-2035

Pilot Space-Based Power Station

2036-2040

Operational Space-Based Power Station

Take-home messages

1. The challenge of achieving a clean energy-rich, Net Zero Europe and world by 2050 is extremely great

2. Recent ESA studies have shown that the **energy transition could be accelerated** by introduction of a new source of green baseload power from space => "**Space-Based Solar Power**", displacing fossil fuel generation plants and thereby contributing to mitigating global warming

3. The are many challenges remaining to realise its potential; some limited R&D efforts are now on-going globally including ESA's SOLARIS initiative, **but more investments are needed now**

The window of opportunity to help solve the energy crisis and contribute to saving the planet is short.

SOLARIS

Towards a world of Clean and Secure Energy

www.esa.int/solaris

Solaris in the news

Solaris video

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