ORBITAL ENERGY

Передача энергии через орбиту

WHO IS BUILDING IT // HOW IT WORKS // WHAT IS PROVEN

MICROWAVE / NEAR-IR LASER / SPACE-TO-SPACE OPTICAL / REFLECTED SUNLIGHT

FIELD MAP // 30 AUG 2026

Свежий обзор по первичным источникам. Компаниям и государственным программам присвоен статус по фактически опубликованным испытаниям, контрактам и разрешениям. Будущие даты указаны как roadmap targets соответствующих организаций.

SYSTEM	FRONTIER	MISSION
ENERGY x COMPUTE x FINANCE	**ORBITAL POWER AS A SERVICE**	**FUND THE DEEP SPACE**

01 // Короткий вывод

EXECUTIVE BRIEF // READ THIS FIRST

К августу 2026 года передача энергии через орбиту уже выглядит как формирующийся рынок. Внутри него существуют четыре разных архитектуры, каждая со своей физикой, экономикой и скоростью выхода на рынок.

1. MICROWAVE / RF	Классическая космическая солнечная энергетика: солнечный свет превращается в электричество, затем в радиочастотный луч и принимается наземной rectenna. Самая глубокая институциональная база у Caltech, JAXA, Китая, Space Solar, NRL/AFRL и Virtus Solis.
2. NEAR-IR LASER	Overview Energy передает энергию широким невидимым near-IR лучом прямо на существующие солнечные панели. Компания показала airborne demo с самолета выше 5 км и подписала с Meta ранний доступ к мощности до 1 GW.
3. SPACE-TO-SPACE OPTICAL	Star Catcher строит орбитальную энергетическую сеть для спутников. Система подает оптическую энергию на штатные солнечные панели клиентов. В 2025-2026 компания прошла наземное испытание свыше 1.1 kW, орбитальное precision tracking и начала подписывать power purchase agreements.
4. REFLECTED SUNLIGHT	Reflect Orbital идет по самому короткому контуру преобразования: орбитальное зеркало отражает солнечный свет на наземные солнечные фермы. FCC выдала лицензию Earendil-1 в июле 2026 года, запуск демонстратора ожидается позже в 2026 году.

Что уже можно считать доказанным

- Caltech MAPLE в 2023 году выполнил беспроводную передачу энергии в космосе и направил обнаружимый сигнал на Землю. Это экспериментальный уровень мощности, но принцип был показан на орбите.
- Китайская программа Xidian в мае 2026 года сообщила 1,180 W на дистанции 100 m при DC-to-DC efficiency 20.8%, а также передачу 143 W на движущийся беспилотник.
- Star Catcher показал более 1.1 kW электрической мощности на коммерческих солнечных панелях в наземном optical power-beaming test и отдельно доказал orbital acquisition and tracking.
- Overview показал реальный атмосферный путь с движущейся платформы выше 5 km и получил коммерческий signal of demand от Meta до 1 GW.
- Space Solar показал 360-degree электронное steering микроволнового луча без механического поворота излучателя.

SpaceBank read-through

Первый банковский продукт вокруг orbital energy, вероятно, появится раньше utility-scale станции в GEO. Уже сегодня формируется договорная основа: power purchase agreements, reservation of beam capacity, delivered-kWh settlement, performance guarantees, orbital service priority и финансирование инфраструктуры передачи. Это делает энергию в орбите потенциальным финансовым активом еще до появления гигантских энергостанций.

SOURCES [02] [07] [10] [14] [15] [17] [20] [26]

02 // Четыре архитектуры

THE MARKET IS SPLITTING INTO FOUR PHYSICAL SYSTEMS

A // MICROWAVE / RF

SUN > PV > DC > RF ARRAY > RECTENNA > GRID

Players: Caltech, Space Solar, China/Xidian, JAXA, Virtus, AFRL/NRL

Edge: Works through cloud/rain bands; mature phased-array theory; utility-scale base-load vision.

Constraint: Very large apertures and rectennas, deployment, spectrum, beam control, conversion losses.

B // NEAR-IR LASER

SUN > PV > DC > NEAR-IR BEAM > PV RECEIVER > GRID

Players: Overview Energy; Aetherflux experiment

Edge: Small optical apertures, precise beams, can reuse existing PV receivers.

Constraint: Cloud/weather, pointing, atmospheric safety case, thermal rejection.

C // SPACE-TO-SPACE OPTICAL

SUN > COLLECTION > OPTICAL BEAM > SATELLITE PV

Players: Star Catcher Industries

Edge: No atmosphere, receiver already exists on client satellite, high-value orbital kWh.

Constraint: Precision tracking, geometry, receiver thermal limits, network orchestration.

D // REFLECTED SUNLIGHT

SUN > ORBITAL MIRROR > GROUND SOLAR FARM

Players: Reflect Orbital

Edge: Few conversion steps and no onboard electric transmitter required.

Constraint: Mirror scale, short illumination windows, astronomy/ecology, licensing and space traffic.

Почему их нельзя сводить в одну цифру эффективности

В microwave system часть энергии теряется на PV, RF conversion, free-space propagation и rectenna conversion. В laser system появляются laser wall-plug efficiency и погодные ограничения. Star Catcher продает услугу в вакууме, где нет атмосферной потери и принимающая солнечная панель уже находится на спутнике. Reflect Orbital вообще переносит свет, поэтому его ключевая метрика связана с irradiance, временем подсветки и площадью зеркал. Сравнение должно идти по delivered useful energy, availability, capex per delivered watt и стоимости приемной инфраструктуры.

Физическая развилка определяет финансовую модель

Architecture	Likely buyer	Contract unit	Main asset
Microwave / RF	Grid / utility / state	MW, MWh, availability	GEO/HEO power station + rectenna
Near-IR laser	Solar farm / data center / utility	MW, MWh, delivery window	Orbital transmitter + terrestrial PV
Space-to-space	Satellite / orbital data center	kW, kWh, beam time	Orbital power node + service network
Reflected sunlight	Solar farm / site operator	irradiance window / MWh uplift	Mirror constellation + targeting rights

03 // Лестница доказательств

WHAT IS REAL TODAY // NOT AN OFFICIAL TRL SCALE

Ниже используется собственная research scale SpaceBank. Она показывает только публичное доказательство конкретного контура передачи энергии. Она не заменяет NASA TRL или внутреннюю оценку компаний.

Level	Evidence	Definition
L0	CONCEPT	архитектура, paper, patent
L1	LAB	компонент или под-система в лаборатории
L2	FIELD / GROUND	полный или почти полный наземный контур
L3	AIRBORNE	передача через реальную атмосферу с движущейся платформы
L4	ORBITAL COMPONENT	ключевой элемент проверен на орбите
L5	ORBITAL POWER TRANSFER	сама передача энергии показана в космосе
L6	CONTRACT / LICENSE	есть коммерческий offtake, PPA или регуляторное разрешение
L7	COMMERCIAL SERVICE	регулярная оплачиваемая поставка мощности

Позиция игроков на 30 AUG 2026

Player	Public level	Why
Caltech SSPP	L5	Orbital WPT in 2023; signal detectable on Earth. Experimental power.
Star Catcher	L4 + L6	Orbital tracking + >1.1 kW ground optical test + customer PPAs. Full orbital power beam pending.
Overview Energy	L3 + L6	Airborne >5 km demo + Meta agreement up to 1 GW + USAF contract.
Reflect Orbital	L6	FCC license for Earendil-1; energy service remains to be demonstrated in orbit.
Space Solar	L2	360-degree RF ground demonstrator; 2027-28 orbital kW milestone is roadmap.
China / Xidian	L2	100 m, 1.18 kW and 20.8% DC-to-DC reported in 2026; orbital tests next.
JAXA	L2	Long-running microwave and laser WPT research; no utility orbital service.
Virtus Solis	L2	100 m 10 GHz phased-array/rectenna test; no public orbital transfer yet.
NRL PRAM	L4	Solar-to-RF conversion tile operated in orbit in 2020; did not beam to Earth.
Aetherflux	L2 / planned	Laser-to-Earth flight experiment planned; strategy increasingly converges with orbital compute.

SOURCES [02] [05] [09] [10] [14] [15] [17] [20] [26] [29] [31] [33]

04 // Overview Energy

NEAR-IR ORBIT-TO-GRID // EXISTING SOLAR AS THE RECEIVER

Architecture

SUN > PV > ELECTRICITY > WIDE NEAR-IR BEAM > STANDARD PV > GRID

Overview proposes geosynchronous power satellites at roughly 36,000 km. The beam is designed as a broad, low-intensity, invisible near-IR illumination field that existing photovoltaic farms can convert back into electricity.

The strategic shortcut: reuse a terrestrial receiver network that already exists. The solar farm becomes both generation asset and orbital energy receiver.

Dr Paul Jaffe

SYSTEMS ENGINEERING // OVERVIEW

Long-time wireless power / space-solar researcher. Previously associated with NRL power-beaming work, now part of Overview's technical team.

Public evidence

Date	Evidence	Meaning
09 DEC 2025	AIRBORNE DEMO	Moving Cessna above 5,000 m transmitted power through atmosphere to standard solar panels.
27 APR 2026	META AGREEMENT	Initial orbital demo targeted for 2028, commercial service targeted for 2030, Meta early access up to 1 GW.
06 MAY 2026	USAF CONTRACT	Assessment of orbit-to-grid power for resilience in constrained or contested environments.

Why this matters

- Overview has one of the clearest commercial bridges from demo to offtake: a real atmospheric path, a named hyperscale buyer and a public 2028/2030 milestone sequence.
- A broad beam and existing PV reduce the need for a purpose-built kilometer-scale rectenna, though cloud cover, pointing, thermal management and orbital asset scale remain core engineering constraints.
- For finance, the most legible instrument is an energy offtake contract measured at the receiving solar facility.

SOURCES [08] [09] [10] [11] [12] [37]

05 // Space Solar

CASSIOPeiA // 360-DEGREE MICROWAVE POWER BEAMING

UK-based Space Solar is developing CASSIOPeiA, a modular space-based solar power architecture. Mirrors concentrate sunlight onto photovoltaics, electricity is converted into microwave RF, and phased arrays steer the beam electronically toward a terrestrial rectenna.

01	02	03	04	05
SUNLIGHT	**MIRROR + PV**	**RF CONVERSION**	**360° ARRAY**	**RECTENNA + GRID**

What has been demonstrated

- HARRIER, announced in 2024, demonstrated 360-degree wireless power transmission without moving the RF structure. This addresses one of the distinctive claims of the CASSIOPeiA architecture: electronic steering across a full hemisphere.
- The 18-month CASSiDi programme, reported complete in April 2025, developed the design and industrial pathway further with UK partners.
- The UK government SBSP de-risking work was refreshed in February 2026 and places Space Solar milestones into a national-scale roadmap.

Public roadmap from the 2026 UK study

Target year	Milestone	Status discipline
2026	Long-distance terrestrial WPT + integrated PV module	Target / anticipated
2027-28	In-orbit demonstration, kilowatt scale	Roadmap
2030	31 MW HEO minimum viable product	Forecast in study
2033	150 MW HEO	Forecast in study
2036	650 MW GEO	Forecast in study

People to track

Martin Soltau and Sam Adlen serve as co-CEOs. Ian Cash is the chief architect and originator of the CASSIOPeiA design. The company is important because it combines a full utility-scale architecture, industrial partners and a public UK roadmap.

SOURCES [05] [06] [07]

06 // Star Catcher Industries

SPACE-TO-SPACE POWER GRID // THE FIRST HIGH-VALUE MARKET MAY ALREADY BE IN ORBIT

SUN > COLLECTION / SPECTRAL CONDITIONING > OPTICAL BEAM > CLIENT SATELLITE PV

Star Catcher is building an orbital power grid for spacecraft. It collects and concentrates solar energy, conditions the light into wavelengths optimized for common satellite solar cells, and beams power to client spacecraft. The receiver is the solar array the satellite already carries.

Structural advantage: the service avoids the atmosphere and targets a market where every delivered watt in orbit can replace launch mass, battery mass or a larger onboard power system.

Andrew Rush

CO-FOUNDER & CEO

Commercial space executive. Star Catcher team also includes CTO Michael Snyder and CBO Bryan Lyandvert.

Evidence and commercialization sequence

Date	Milestone	Public evidence
21 MAR 2025	100 m end-to-end ground test	Concentrated solar energy delivered to multiple commercial satellite solar arrays.
04 NOV 2025	>1.1 kW optical test	Multi-wavelength lasers produced more than 1.1 kW electrical output on COTS solar panels at Kennedy/Space Florida.
LATE 2025	On-orbit tracking demo	Sextant Alpha demonstrated precision acquisition and tracking; result announced 09 APR 2026.
12 MAY 2026	$65M Series A	Company reported total capital raised of $88M.
24 AUG 2026	Aethero PPA	Power purchase agreement with orbital compute company Aethero; company described it as its tenth major commercial customer.

SpaceBank interpretation

Star Catcher is the clearest example of orbital energy becoming a service contract before a terrestrial grid product. Beam time, guaranteed delivered power, priority and availability can all become contractible units. The company still needs to demonstrate actual power transfer in orbit, but the commercial layer is forming in parallel with the hardware layer.

SOURCES [13] [14] [15] [16] [17]

07 // Reflect Orbital

REFLECTED SUNLIGHT // LIGHT LOGISTICS FROM ORBIT

SUN > ORBITAL MIRROR > EXISTING SOLAR FARM

Reflect Orbital skips onboard electrical conversion and RF/laser generation. A mirror in low Earth orbit redirects sunlight toward a terrestrial target. The initial commercial narrative focuses on extending solar production around dusk and dawn.

Important distinction: this is a transport system for photons. Its economics depend on mirror area, orbital geometry, delivered irradiance and duration of the illumination window.

Ben Nowack

CO-FOUNDER & CEO

Reflect Orbital is building a constellation of controllable space mirrors and a software layer for booking illumination.

2026 status

- The FCC Space Bureau granted a license for the Earendil-1 demonstration mission on 9 July 2026. The launch remains a future milestone as of this review date.
- The first demonstrator is an 18 m class reflector in public technical descriptions. The company roadmap starts with a small number of satellites and scales toward longer, higher-irradiance illumination windows.
- Reflect Orbital publishes targets around 2030 and 2035 for solar capacity-factor uplift. These values are company roadmap targets, not demonstrated performance.

Main externality: the sky itself

COMMERCIAL CASE

Low conversion stack, existing PV receiver, highly legible user experience: book reflected sunlight at a known place and time.

REGULATORY / ENVIRONMENTAL CASE

Astronomy, light pollution, wildlife and space-traffic impacts become first-order constraints. An August 2026 arXiv analysis modeled significant atmospheric skyglow for large-scale mirror systems, and DarkSky groups challenged the FCC approval.

SOURCES [18] [19] [20] [21] [22]

08 // Caltech + NRL

THE ORBITAL PROOF LAYER // FROM CONVERSION TO WIRELESS TRANSFER

Caltech Space Solar Power Project

In June 2023 the MAPLE experiment aboard Caltech's Space Solar Power Demonstrator wirelessly transferred power in space and directed a signal that was detected on Earth. The SSPD-1 mission concluded in January 2024 after validating wireless transfer, photovoltaic behavior and lightweight deployable structures.

A 2025 technoeconomic analysis modeled a distributed 10 GHz GEO system. Under its assumed ten-year technology maturation and scale-up path, the paper reports a modeled LCOE of about 9.4 cents/kWh. Its end-to-end efficiency cases remain demanding, around 2.77% to 6.63% across current, middle and asymptotic assumptions.

Sergio Pellegrino, Harry Atwater, Ali Hajimiri

CALTECH SSPP PRINCIPAL INVESTIGATORS

NRL PRAM: an earlier orbital precursor

The U.S. Naval Research Laboratory launched the Photovoltaic Radio-frequency Antenna Module, PRAM, on the X-37B in May 2020. The 12-inch tile converted sunlight into RF energy in orbit. It did not beam power to Earth, so PRAM proved an orbital conversion block rather than a complete orbit-to-ground energy link.

CONTINUITY OF PEOPLE AND IDEAS

Paul Jaffe, one of the long-running figures in U.S. space solar and power beaming, appears today in Overview Energy's systems engineering team. That continuity matters: the commercial wave is inheriting decades of government and academic hardware knowledge.

SOURCES [01] [02] [03] [04] [12] [33]

09 // China + JAXA

THE DEEP INSTITUTIONAL PROGRAMS

China: Xidian University + China Academy of Space Technology

China is currently publishing some of the strongest full-chain ground numbers in the field. Xidian University's Sun-Chasing project reported its second-phase results in May 2026.

Test	Reported value	Why it matters
Static wireless link	100 m / 1,180 W / 20.8% DC-to-DC	Meaningful delivered power and system-level efficiency at field scale.
Moving receiver	30 m / 143 W / 30 km/h drone	Adds dynamic pointing and tracking to the energy link.
OMEGA 2022 heritage	55 m / 2,081 W transmitted / 736 W DC output	Earlier full-link prototype at 5.8 GHz; published total system efficiency about 1.15%.

A July 2026 review by researchers from the Qian Xuesen Laboratory / China Academy of Space Technology summarizes two decades of development and explicitly points toward further in-orbit verification, high-voltage high-power generation and management, high-efficiency WPT, and future links to space data centers.

JAXA: microwave and laser in parallel

- JAXA continues research on both microwave and laser space solar power systems and large deployable structures, with practical application positioned in the latter half of the 21st century.
- Its microwave work includes kW-class 5.8 GHz transmission at 50 m and published beam-pointing control around 0.15° RMS.
- The laser branch studies continuous-wave power around 1070 nm.
- JAXA public materials are useful for scale discipline: a conceptual 1 GW microwave station can require a receiving antenna on the order of 2-3 km.

Why this block matters

China and Japan treat wireless power transmission as a long-horizon infrastructure technology, not only as a venture-market product. Their work provides data on efficiency, beam control, receiver size, large-space-structure deployment and operational safety that private companies will ultimately have to confront at scale.

SOURCES [25] [26] [27] [28] [29] [30]

10 // Other serious programs

VIRTUS SOLIS // AETHERFLUX // ESA // AFRL

VIRTUS SOLIS // 10 GHz MICROWAVE

John Bucknell's team is developing a modular microwave SBSP architecture. Its 2023 public test used a 1.92 m transmit aperture with 6,400 elements and a 1.32 x 1.62 m rectenna over 100 m, including multi-target electronic beam steering. Public orbital power transfer has not yet been demonstrated.

SOURCES [31] [32]

John Bucknell
FOUNDER & CEO

AETHERFLUX // LASER + ORBITAL COMPUTE

Founded by Baiju Bhatt, Aetherflux originally emphasized laser power transmission from LEO to Earth. By 2026 the company was also pushing toward orbital data centers, with a Galactic Brain satellite target in Q1 2027. Public reporting indicates the Earth-power programme has been deemphasized while a laser transmission experiment remains planned.

SOURCES [23] [24]

ESA SOLARIS // EUROPEAN R&D

ESA still maintains an active research cluster around solar power satellites and wireless power transmission. Its public material covers microwave, laser and in-space uses. A full operational European deployment decision after the earlier SOLARIS studies is not clearly evidenced in the primary public material reviewed here.

SOURCES [34] [35]

AFRL SSPIDR / ARACHNE // MILITARY R&D

AFRL and Northrop Grumman developed sandwich-tile hardware designed to convert sunlight to RF and beam power to Earth. Public fact sheets expected an Arachne flight experiment, but this review did not find a fresh primary-source confirmation of a completed orbital power-beaming mission by 30 August 2026.

SOURCES [36]

Signal to watch: energy and compute are converging

Aetherflux is moving toward orbital compute. Star Catcher has signed an energy PPA with orbital-compute company Aethero. The Chinese 2026 review explicitly discusses future space data centers. Orbital energy and orbital compute are beginning to form one market architecture: power generation, power routing, compute load, settlement and capacity financing.

SOURCES [17] [23] [24] [25]

11 // People to watch

THE FIELD IS SMALL ENOUGH THAT PEOPLE STILL MATTER

Andrew Rush

STAR CATCHER // CEO

Building the commercial space-to-space energy grid and customer PPA layer.

SRC [13] [17]

Paul Jaffe

OVERVIEW // SYSTEMS

Long-running U.S. wireless-power researcher linking government heritage with the new commercial market.

SRC [12] [33]

Ben Nowack

REFLECT ORBITAL // CEO

Pursuing controllable reflected sunlight as an energy service from LEO.

SRC [22]

John Bucknell

VIRTUS SOLIS // CEO

Former SpaceX Raptor principal engineer building modular microwave space solar power.

SRC [32]

Sergio Pellegrino / Harry Atwater / Ali Hajimiri

CALTECH SPACE SOLAR POWER PROJECT

Structures, photovoltaics and RF integrated into the SSPD/MAPLE experiment that produced the strongest orbital wireless-power proof to date.

SOURCES [01] [02] [03]

Additional names worth tracking

Person	Institution	Why watch
Ian Cash	Space Solar	Chief architect and originator of CASSIOPeiA.
Martin Soltau / Sam Adlen	Space Solar	Co-CEOs driving UK industrial and government path.
Darko Filipi / Abdullah Al-Shakarchi	Overview	Co-CEOs scaling the orbit-to-grid commercial programme.
Hou Xinbin	CAST / Qian Xuesen Lab	Lead author in the 2026 China SBSP review.
Duan Baoyan	Xidian University	Academic leader associated with OMEGA / Sun-Chasing programme.
Baiju Bhatt	Aetherflux	Founder/CEO connecting laser power beaming with orbital compute.

Image credits: Star Catcher Industries; Overview Energy; Reflect Orbital; Virtus Solis; Caltech / Steve Babuljak. Images are included for research identification and source attribution.

12 // Timeline

2020-2036 // PROVEN EVENTS VS ROADMAP TARGETS

A // PUBLICLY REPORTED EVENTS

Year	Actor	Public event
2020	NRL PRAM	Solar-to-RF conversion tile operates in orbit on X-37B; no Earth beam.
2023	Caltech MAPLE	Wireless power transfer in space; signal detectable on Earth.
2024	Space Solar HARRIER	360-degree wireless power transmission demonstrated on ground.
2025	Star Catcher	100 m solar delivery test, then >1.1 kW optical power-beaming test.
2025	Overview	Airborne power beaming from moving aircraft above 5 km to standard PV.
2025	Space Solar	CASSiDi study completed.
2026	Star Catcher	On-orbit acquisition/tracking result, $65M Series A, Aethero PPA.
2026	Overview	Meta agreement up to 1 GW and U.S. Air Force contract.
2026	China / Xidian	100 m, 1,180 W, 20.8% DC-to-DC; moving-receiver test.
2026	Reflect Orbital	FCC license for Earendil-1 demonstrator.

B // ORGANIZATION ROADMAP TARGETS

Year	Actor	Target
LATE 2026	Reflect	Earendil-1 launch/demo target.
LATE 2026	Star Catcher	Orbital power-beaming demonstration intended by company.
Q1 2027	Aetherflux	First Galactic Brain orbital data-center target.
2027-28	Space Solar	Kilowatt-scale in-orbit demonstrator target in UK study.
2028	Overview	Initial orbital demonstration target.
2030	Overview	Commercial service target.
2030	Space Solar	31 MW HEO MVP forecast in UK study.
2030	Reflect	Roadmap target for +1% solar capacity factor at 50 W/m2 for 20 min.
2035	Reflect	Roadmap target for +20% capacity factor with 300 W/m2 for 3 h.
2036	Space Solar	650 MW GEO forecast in UK study.

Discipline: roadmap dates are quoted from company/government materials. They are not SpaceBank forecasts and should be rechecked before publication or investment use.

13 // What becomes finance

THE BANKABLE LAYER AROUND ORBITAL ENERGY

Once energy can be measured, directed and delivered across orbital distance, finance gets a new native asset class. The first instruments can be built around service rights and cash flow before the final utility-scale architecture exists.

POWER PURCHASE AGREEMENT Contract for delivered orbital power over time. Already visible in Star Catcher customer structure.	**BEAM-TIME RESERVATION** Right to a specific power-delivery window, orbital geometry and priority class.	**CAPACITY RIGHT** Reservation of kW/MW availability, analogous to capacity markets and data-center power reservations.
DELIVERED-kWh SETTLEMENT Metered energy at the receiver becomes a clean settlement unit for automated payments.	**SERVICE PRIORITY** Premium right to power during eclipse, peak compute load, emergency or degraded onboard generation.	**PERFORMANCE GUARANTEE** Contractual floor for power, availability, pointing accuracy, irradiance or receiver performance.
INSURANCE Coverage for launch, deployment, pointing failure, receiver damage, service interruption and regulatory shutdown.	**ASSET FINANCE / COLLATERAL** Financing of transmitters, mirrors, rectennas, ground PV receiver rights and orbital energy nodes.	**MACHINE PAYMENTS** Satellites and orbital data centers can autonomously buy power as an operating input.

Likely order of monetization

1. Space-to-space power service. 2. Contracted orbit-to-grid demonstrations and site-specific delivery. 3. Reflected-light windows. 4. Large multi-hundred-megawatt microwave infrastructure. This ordering is a SpaceBank assessment based on receiver reuse, atmospheric complexity, capex scale and currently visible commercial demand.

ENERGY BECOMES BANKABLE WHEN THE SYSTEM CAN PROVE:

WHO DELIVERED HOW MUCH POWER, TO WHOM, WHERE, WHEN, UNDER WHICH PRIORITY, WITH WHICH FAILURE RULE.

SpaceBank thesis connection

Orbital energy is the bridge between energy infrastructure and orbital compute. If compute moves outward, energy supply, contracts, identity, collateral, insurance and autonomous settlement follow it. That is exactly the point where an off-world financial system stops being a thought experiment and starts becoming infrastructure.

14 // System bottlenecks

THE HARD PROBLEMS ARE DIFFERENT FOR EACH ARCHITECTURE

Constraint	Microwave/RF	Near-IR Earth	Space-to-space	Reflected light
End-to-end efficiency	High	High	Medium	Low conversion stack
Atmospheric weather	Low-medium below ~10 GHz	High	None	Cloud optical path / scattering
Beam / pointing precision	High	Very high	Very high	High orbital targeting
Receiver infrastructure	Very large rectenna at utility scale	Existing PV possible	Existing spacecraft PV	Existing solar farm / target area
Large space structures	Very high	High	Medium-high	Very high mirror area at scale
Thermal rejection	High	High	High on receiver/transmitter	Lower onboard conversion heat
Spectrum / optical safety	RF spectrum + human safety	Laser safety + aviation	Spacecraft safety / coordination	Brightness / public-space effects
Regulatory path	Spectrum, grid, land, space	Optical, aviation, grid, space	Space traffic + commercial service	FCC, astronomy, light pollution, space traffic
Commercial demand visible now	Early / institutional	High signal via Meta	High signal via PPAs	Early, service pre-demo

The three gates that decide the market

- Gate 1, unit economics: launch and in-space assembly must fall faster than the capex burden of larger orbital apertures rises.
- Gate 2, autonomous control: precision tracking, fail-safe beam shutdown and power routing must operate with very high availability.
- Gate 3, regulation and public legitimacy: RF spectrum, optical safety, astronomy, land-use and space-traffic rules can determine deployment speed as much as the physics.

What to monitor monthly

Actual delivered watts. Distance. End-to-end efficiency. Receiver size. Duty cycle. Weather availability. Beam-control accuracy. Flight hardware mass. Launch/assembly plan. Signed offtake. Regulator action. Insurance terms. These indicators will show which architecture is becoming infrastructure first.

15 // Sources

PRIMARY SOURCES FIRST // FULL SOURCE LEDGER

Method: preference is given to primary company, university, government and peer-reviewed sources. Independent press is used to cross-check selected commercial claims. Company-reported customer counts, funding totals and future milestones are labeled as such in the body.

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