Cleantech Forum
San Francisco

The Rising Stars

The Rising Stars

MODERATED BY

KATIE MCCLAIN

Director, Market Development, Energize Ventures

The Rising Stars

MATT HARPER

President & Chief Product Officer, Avalon Battery

Cleantech Forum 2019
Rising Stars Session

Matt Harper
President and Chief Product Officer
mharper@avalonbattery.com

• December 2018

Avalon Overview

Avalon designs, builds and delivers the world's most dependable flow batteries.

- → MW-scale projects with leading customers in the US and China
- → Externally validated lowest total cost of ownership
- → Targeting the rapidly maturing long-duration, heavy duty cycle storage market.
- → Largest fleet of identical flow batteries ever installed (140+ units in operation)

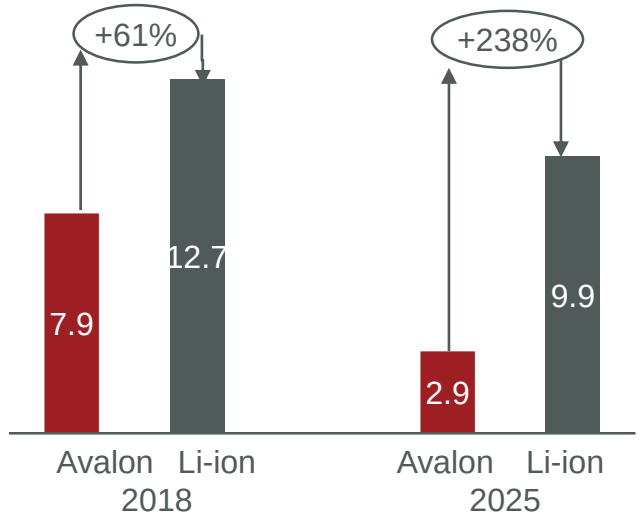
AVALON BATTERY

Avalon’s product: standardization as the path to low cost and reliability

Most flow batteries: Built in place, high construction costs, poor reliability

Avalon flow battery: 13 years’ work yields world’s first turn-key, factory manufactured vanadium flow battery:

Result: Durable technology and manufacturing scale yield ultra-low total cost of ownership ($USD LCOS, below)

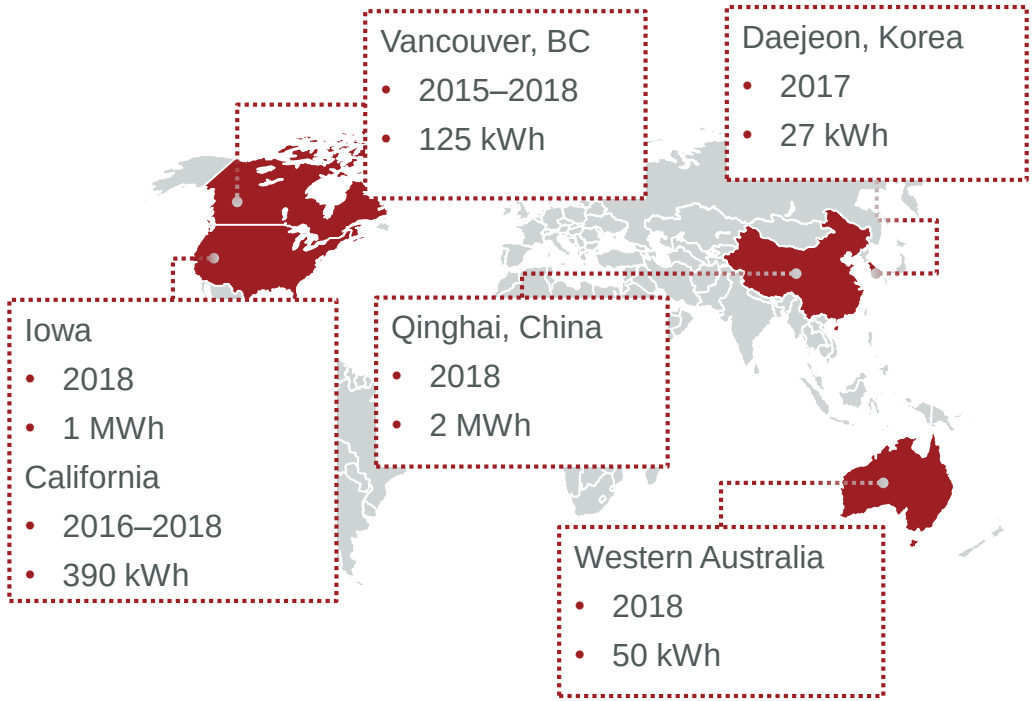


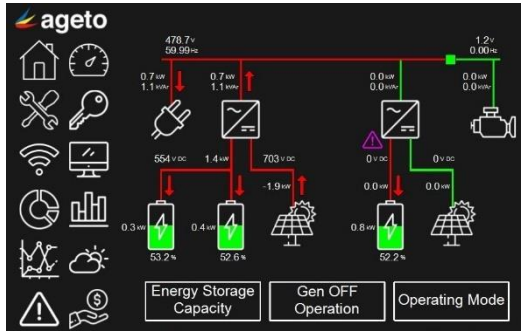
Avalon’s highly standardized approach yields:

- ✓ Proven reliable performance for decades of deep cycles
- ✓ Economies of scale and quality assurance for entire product
- ✓ Low-cost, reliable turn-key installation at site
- ✓ Lowest full-lifecycle total cost of ownership

Avalon established and growing across fastest growing geographies and applications for storage

Current Avalon's installations





Industrial facility in Santa Cruz, CA using solar storage to power facility, avoiding interconnection and energy costs

Avalon Solution: 90kWh, 30kW AFB2

Operational November 2018

IRR (unlevered): 140%

Industrial customer in Pomona, CA using storage to mitigate demand charges and shift energy alongside existing PV array

Avalon Solution: 90kWh, 30kW AFB2

Operational October 2017

IRR (unlevered) 22%

US renewable energy project will use batteries to reduce clipping and optimize plant, boosting energy delivered under PPA

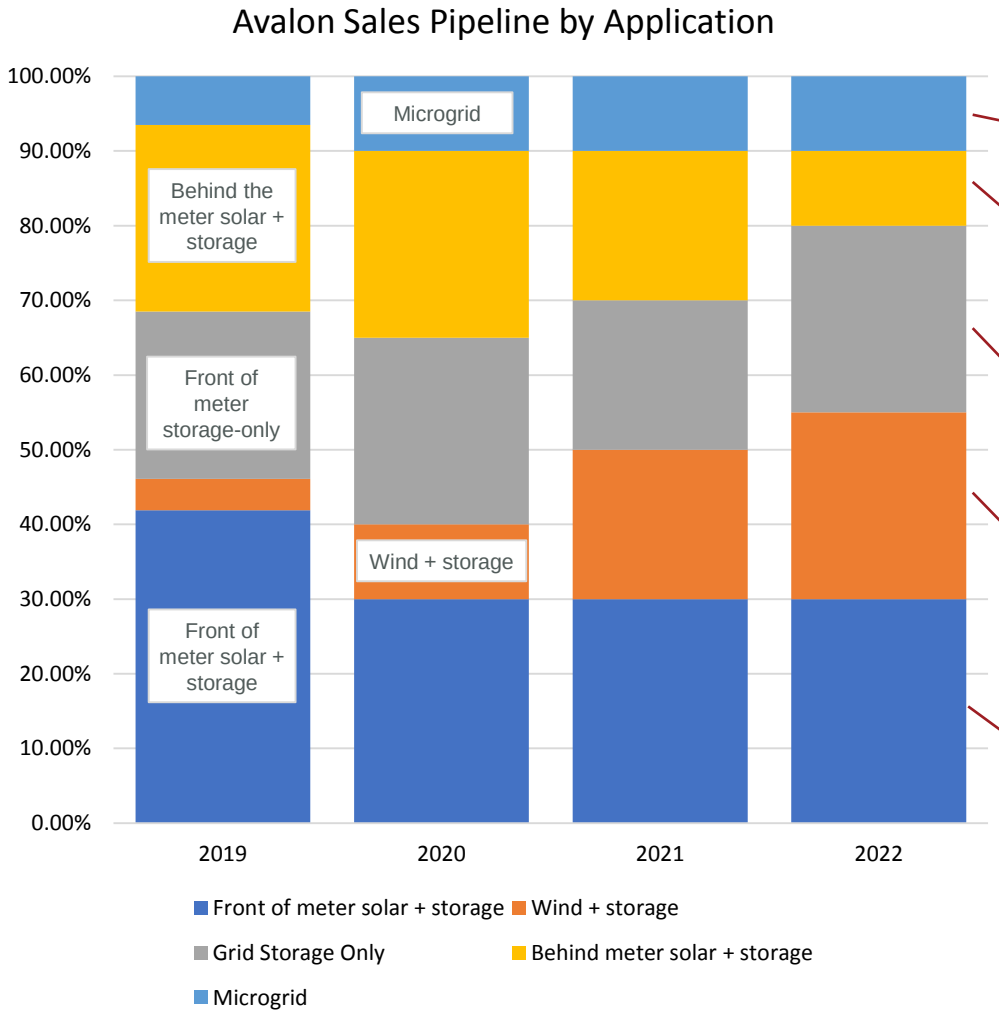
Avalon Solution: 4MW, 16MWh AFB3

Proposal delivered; COD anticipated Q4 2019

IRR (unlevered) 11.3%

AVALON BATTERY

Evolution of pipeline over next four years



Long Run Drivers

Microgrid	• Huge opportunity in developing world (BRICS+ industrials) • Large industrials (eg mines) likely to dominate volume early
Behind the meter solar + storage	• Continued expansion of BTM sales model • Scale of individual projects small
Front of meter storage-only	• Significant growth as capacity markets expand and business models standardize. • Single project size very larger
Wind + storage	• First projects in China underway; ROW to follow.
Front of meter solar + storage	• PPA structures in USA starting to require storage as an option. • Combination of PPA adder and capacity payments = stable model for growth.

AVALON BATTERY

Looking to the future

1

Product Differentiation

- Longer duration applications gain traction
- Contract terms will extend beyond 10 years
- Duty cycles will drive technology specialization

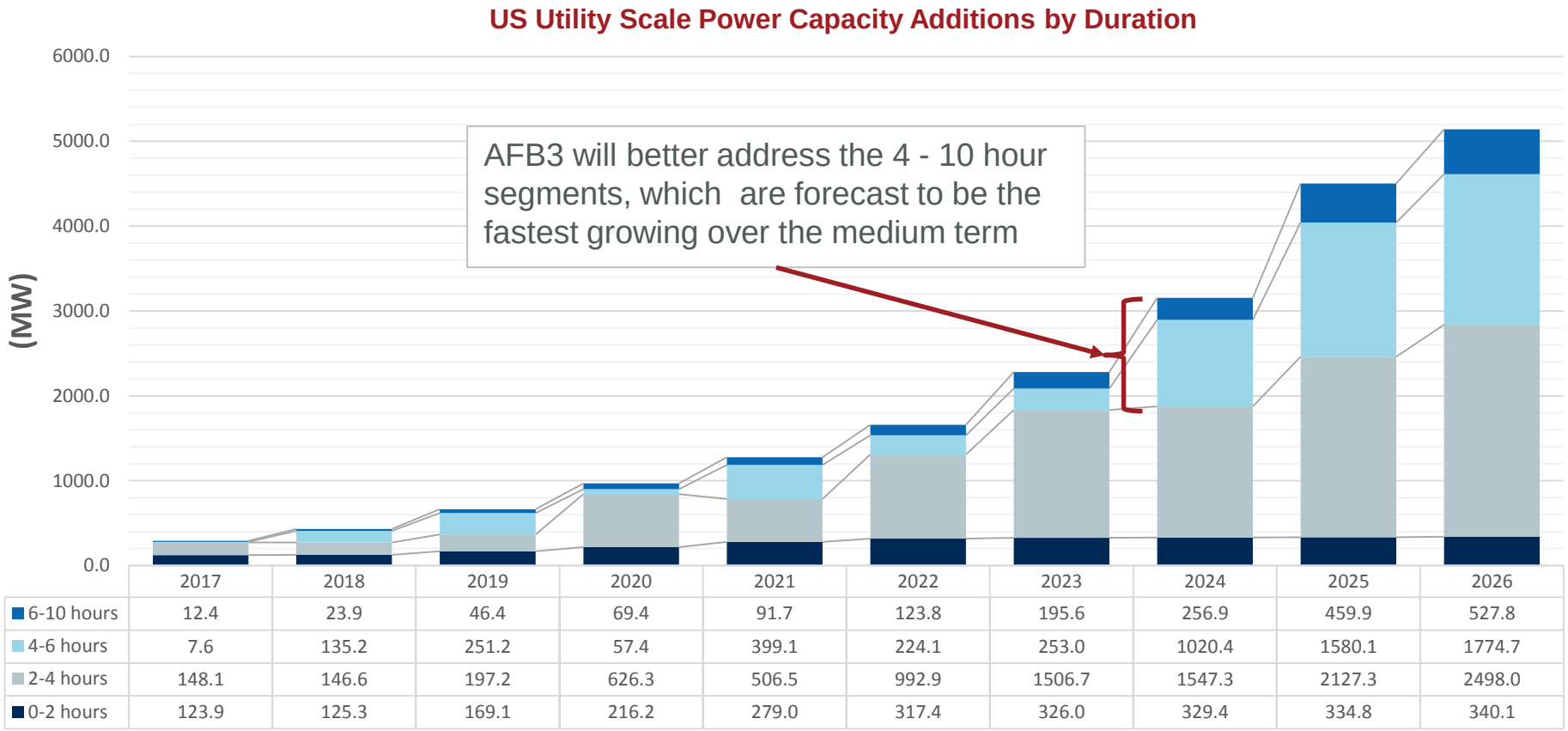
2

Standard Commercial Models

- Niche and policy-driven projects will be fewer
- Standardized applications will emerge
- Standardized financial and contract structures will follow

Product differentiation

Long- and short-duration storage applications will co-exist



	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
6-10 hours	12.4	23.9	46.4	69.4	91.7	123.8	195.6	256.9	459.9	527.8
4-6 hours	7.6	135.2	251.2	57.4	399.1	224.1	253.0	1020.4	1580.1	1774.7
2-4 hours	148.1	146.6	197.2	626.3	506.5	992.9	1506.7	1547.3	2127.3	2498.0
0-2 hours	123.9	125.3	169.1	216.2	279.0	317.4	326.0	329.4	334.8	340.1

Navigant - Country Forecasts for Utility-Scale Energy Storage, 2017

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Product differentiation

Different storage solutions will serve different needs

Lithium-ion

- Cost competitive for short-duration applications
- Short life in terms of cycles and years
- Established product with good bankability

►**Best suited for power-focused applications**

Avalon

- Cost competitive for longer-duration applications
- Long life in terms of cycles and years
- Emerging product with improving bankability

►**Best suited for the energy-focused applications**

Analogy to internal combustion engines

Ford EcoBoost M-6007-35T

- Power: 365 hp
- Cost: 9,600 USD
- Design life: 3,500 hr
- **Specific cost: 26 USD/hp**

►**Best suited for power-focused applications**

Caterpillar CATC 1.1

- Power: 20 hp
- Cost: 4,000 USD
- Design life: 100,000 hr
- Specific cost: 200 USD/hp

►**Best suited for energy-focused applications**

AVALON BATTERY

Standard commercial models

Low total LCOE = Renewables plus storage as new baseload

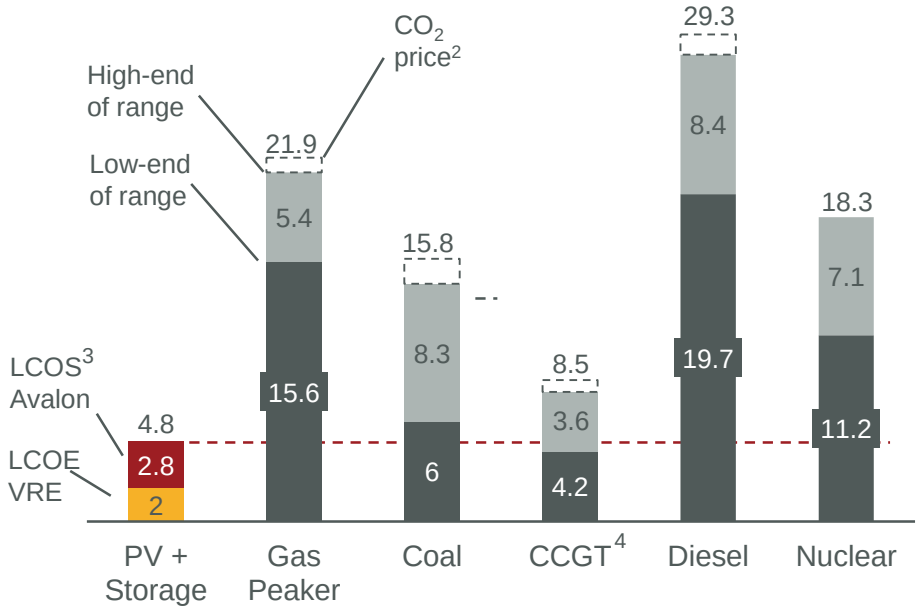
Need for new generation capacities due to

Retirement
- Policy-driven retirement of conventional generators
- Retirement of old generators

Flexibility need
- Demand for more dispatchable generators due to high VRE share

Demand growth
- Emerging markets: Overall market growth
- Mature markets: Electric vehicle adoption, etc.

LCOE comparison[1] (USDct/kWh)



1) Values for conventional energy sources based on „Lazard's levelized cost of energy analysis – Version 11.0" (Nov 17), see backup slide;
2) Conservative assumption of August 2018 values in EU (17.5 EUR/tCO_2 ~ 20 USD/tCO_2); 3) Assumptions for 2025; 4) Combined cycle gas turbine

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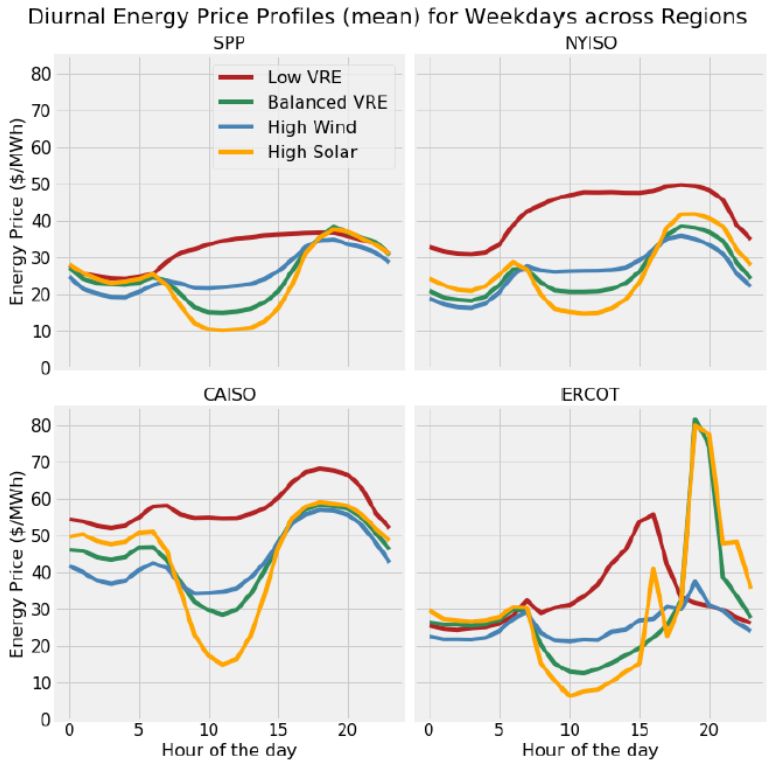
Standard commercial models

Time shifting driven by market price signals

BERKELEY LAB
Lawrence Berkeley National Laboratory

Report:
"Impacts of High Variable Renewable Energy Futures on Wholesale Electricity Prices, and on Electric-Sector Decision Making"



Profitable operation based on Avalon's 2025 LCOS of 28 USD/MWh for market-based "time-shift only"

Economical addition of energy storage to VRE possible with increasing share of renewables[1], e.g., at a total share of 40% – expected to be reached between 2020 and 2030 depending on market[2]

1) See following slide for assessment; 2) CleanTechnica (2017) – 50% CAISO renewables target for 2030 expected to be reached by 2020

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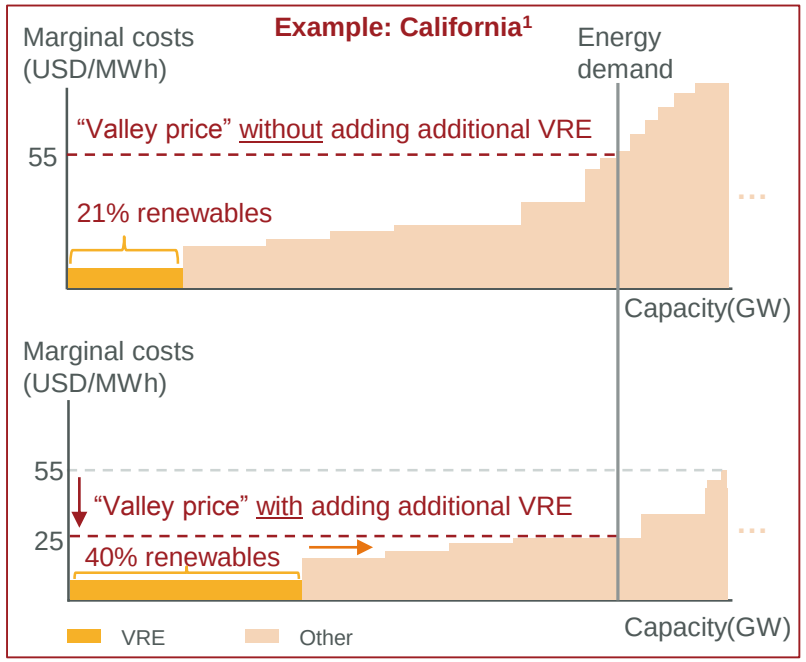
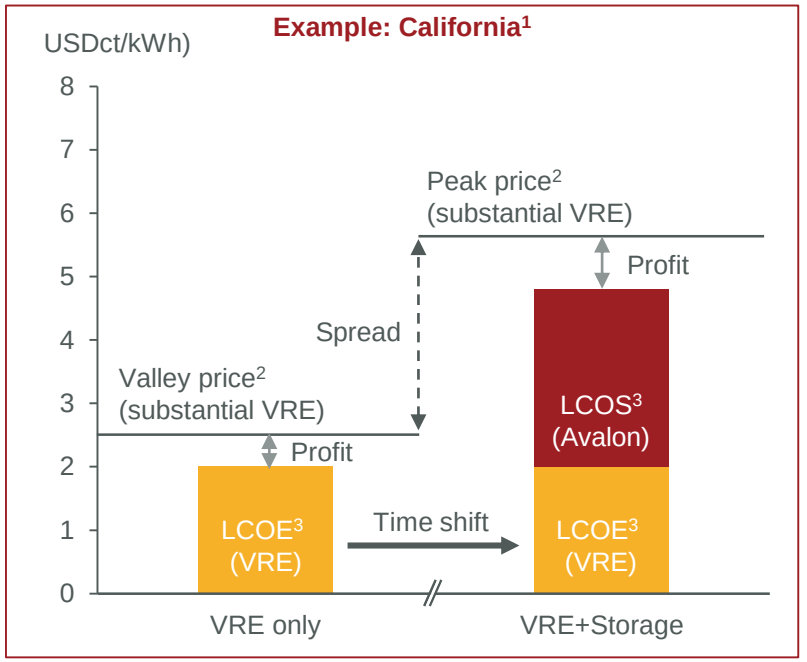
Standard commercial models:

Demand curve getting steeper, increasing opportunities for arbitrage





- Price setting based on marginal cost of most expensive plant ("merit order")
- Increasing share of VRE leading to lower valley prices ("merit order effect")
- Independent from VRE, peak prices may increase, further widening the spread

- New VRE and storage assets must be financed based on expected electricity prices, i.e., the applicable price must be higher than the LCOE
- Spreads between peak and valley price that are larger than LCOS make it economically feasible to add storage to VRE and time shift the electricity

1) See study results by Berkely Labs on next slides, „High solar" scenario"; 2) Valley and peak price set by marginal costs of most expensive plant that is required („merit order", see left); 3) Assumptions for 2025

AVALON BATTERY

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- December 2018

The Rising Stars

JO-JO HUBBARD

COO & Co-Founder, Electron

ELECTRON

Cleantech Forum: Rising Stars

January 29th 2019

Electron thesis

Mission

Design and build the digital infrastructure that enables the transition to cheaper, greener, cleaner power

Infrastructure thesis

Increasingly complex markets and contractual relationships will be indexed by a shared asset register

Blockchain thesis

The coordination mechanism to align incentives and create transparency between market participants

Problem: inability to determine value in increasingly complex systems

1 Data fragmentation

- Siloed, inconsistent and missing data – no view of the whole system

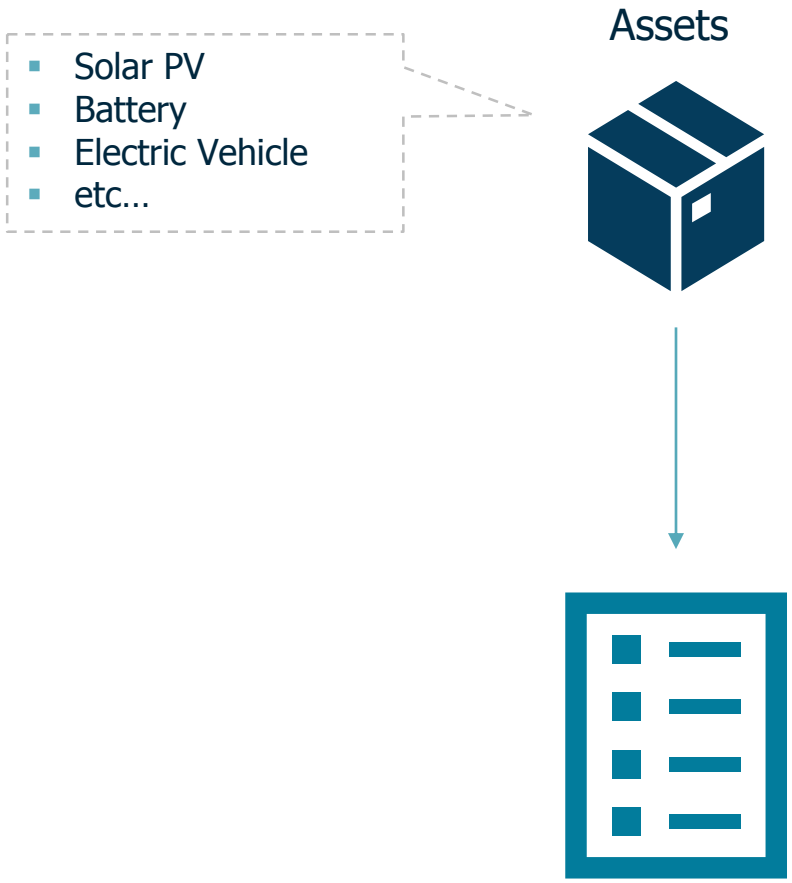
2 Identity fragmentation

- Assets with multiple contractual relationships can have multiple identities

3 Market fragmentation

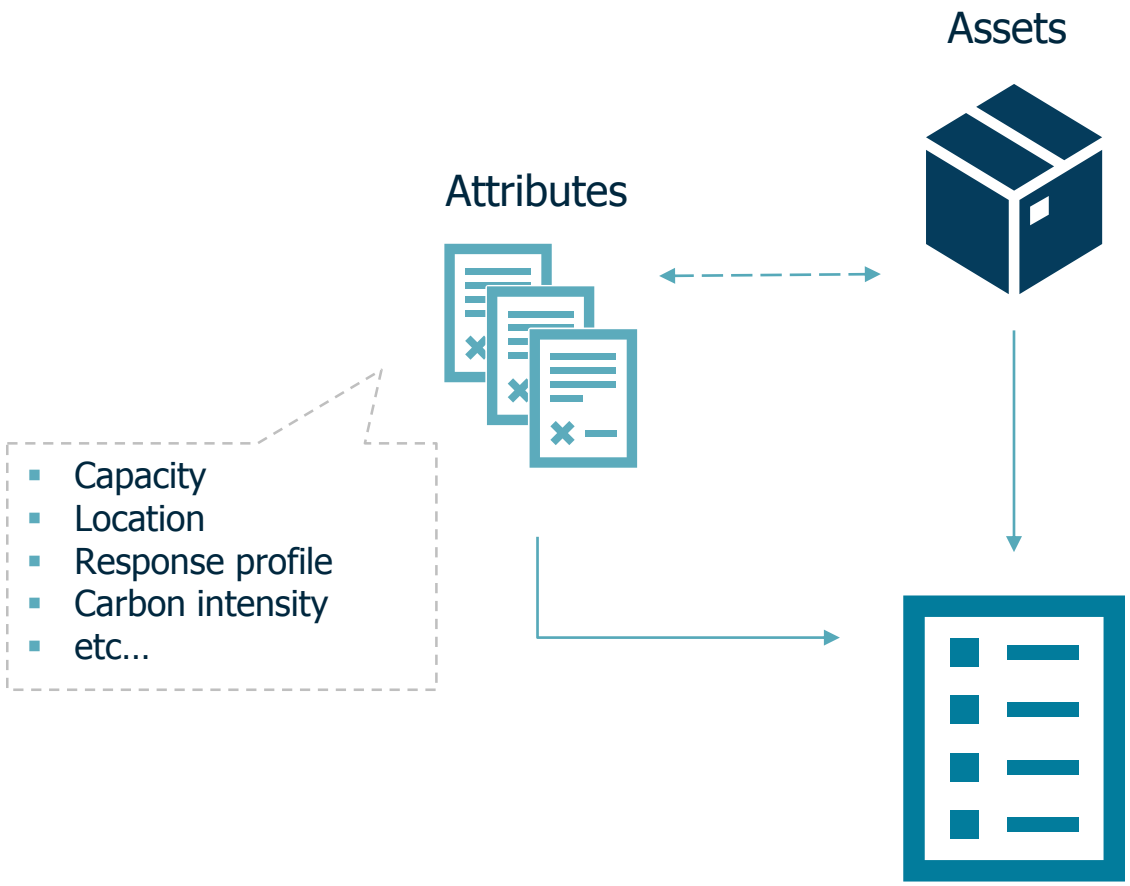
- Can’t capture most efficient action as impossible to work this out due to the above

Our solution: a shared asset register for attributes & contractual relationships



1. Permissioning and access
2. KYC (root of trust)
3. Provenance (stream of trust)
4. Data Integrity

Our solution: a shared asset register for attributes & contractual relationships



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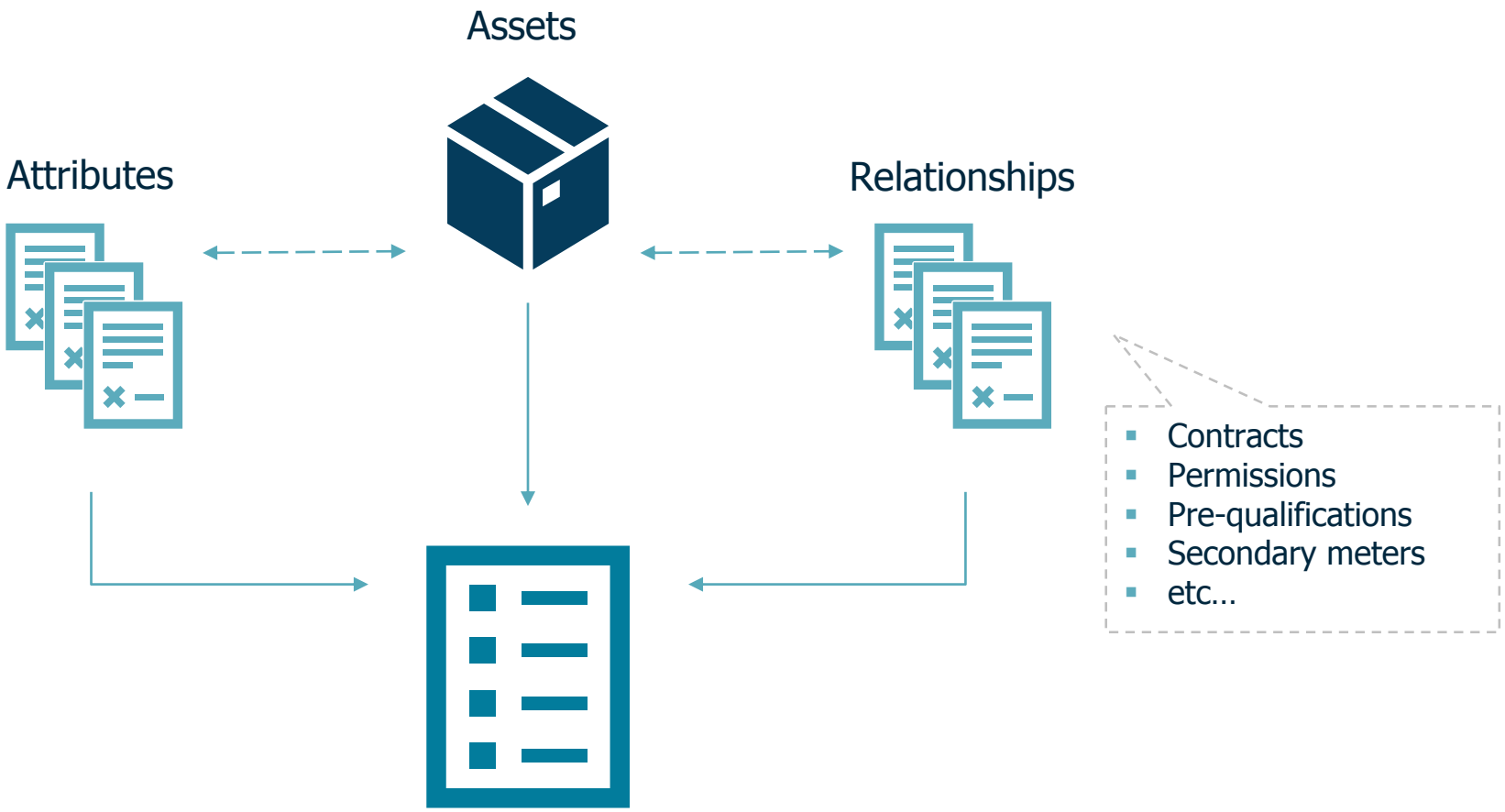
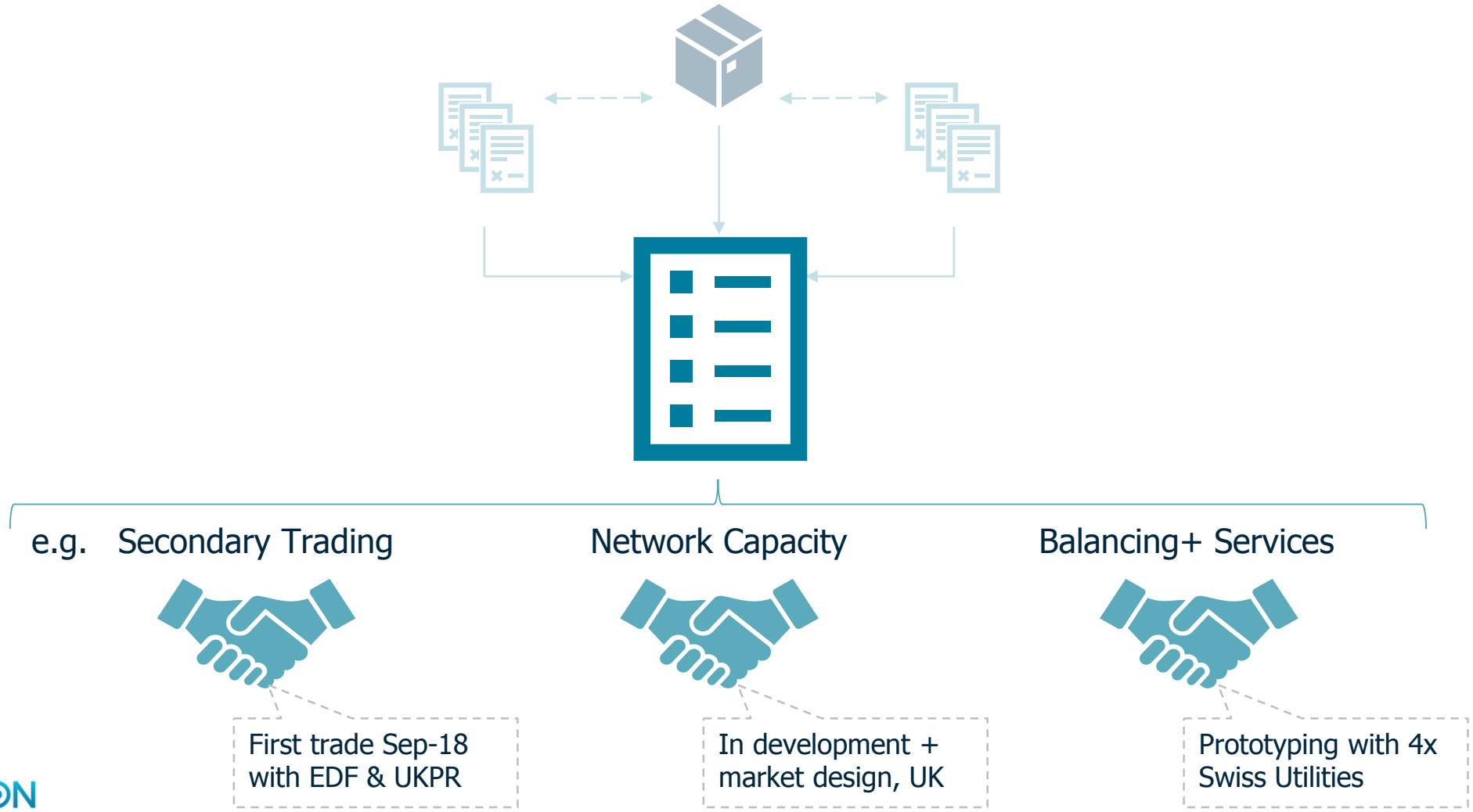


… provides the basis for new markets and services



Any questions?

The Rising Stars

KEVIN NOERTKER

CEO, Ampaire

2019 Cleantech Forum:

Rising Stars

Diversity of Thought

AMPAIRE

Commercial Electric Aircraft

Kevin Noertker Co-Founder & CEO
kevin@ampaire.com


wideroe.no


AMPAIRE

AMPAIRE

The Third Revolution In Aviation Has Begun


AMPAIRE

Massive Benefits:


70% - 90% fuel cost savings


25% - 50% maintenance cost savings


Ultra quiet takeoffs and landings


Zero Direct Emissions

Meaningful Impact:


New Flights

Extended Hours of Operation


More People Will Be Flying


Connecting Communities

Our Mission

Trusted

Practical

Compelling

Electric Aircraft

AMPAIRE

Our Vision

Flight are more accessible

to more people from more airports

with electric aircraft that are

safe, clean, quiet and less costly.

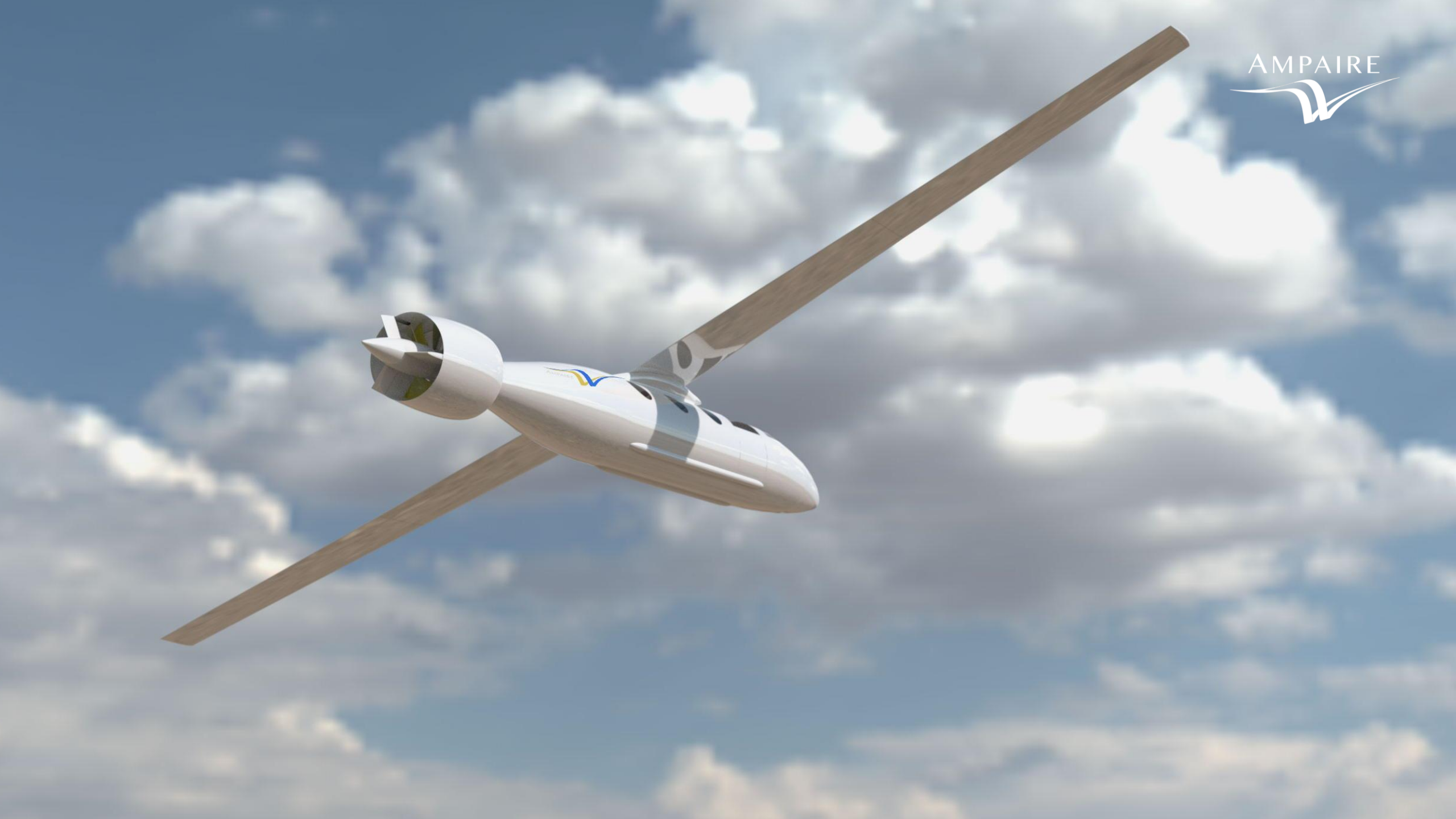
AMPAIRE

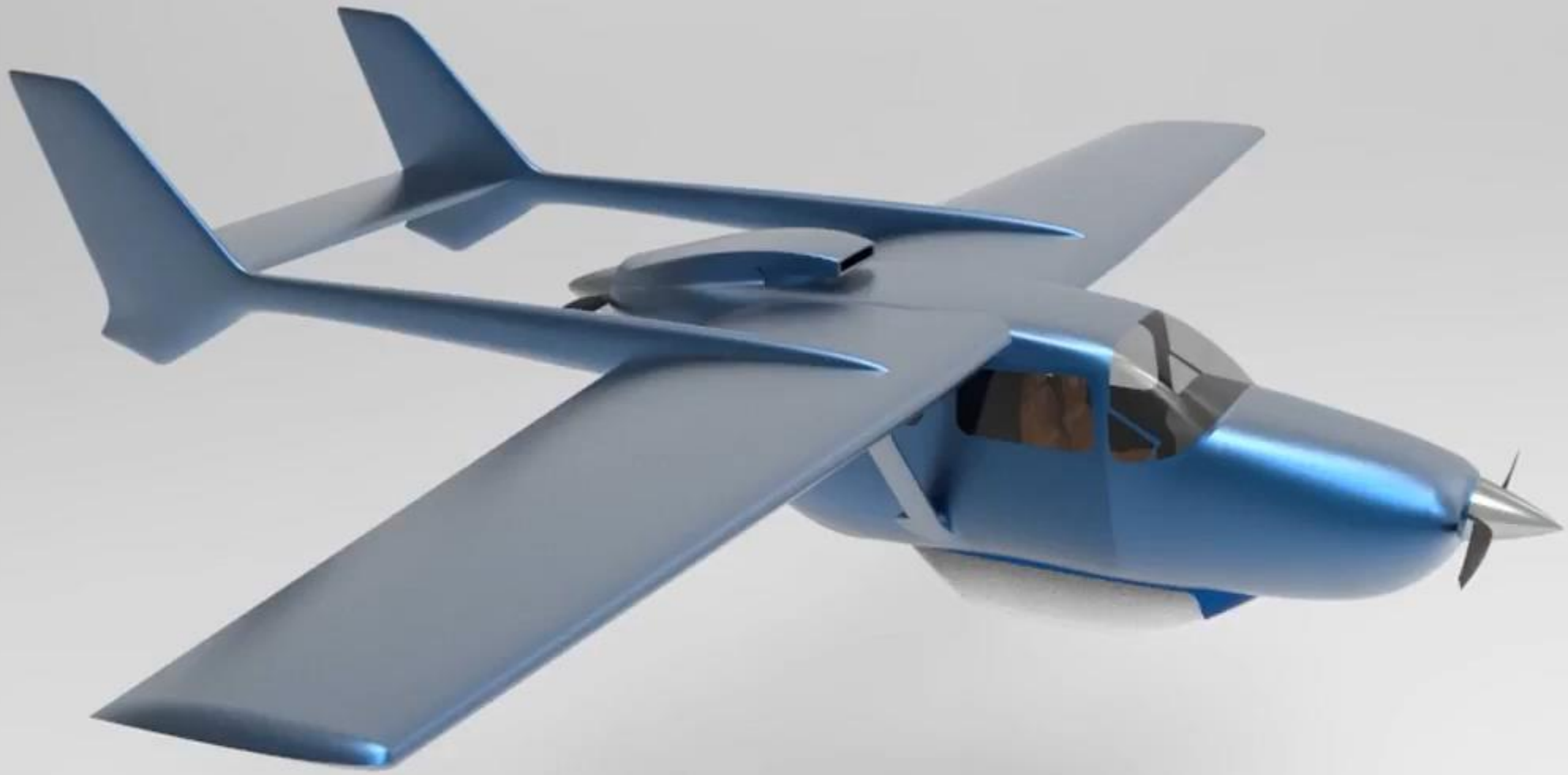
Our Flight Plan

Pragmatic

Step-by-step

Lean, Agile, Scalable


AMPAIRE



AMPAIRE

BOEING

MIT

GM

GE

Virgin GALACTIC

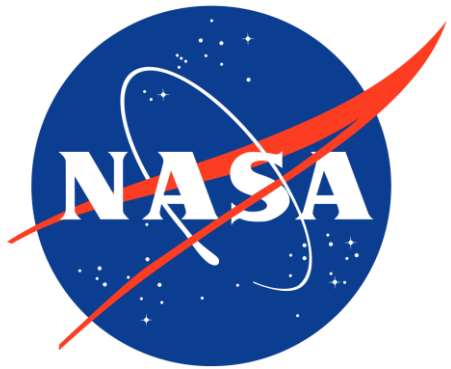
NORTHROP GRUMMAN

SPACEX

Stanford University

Caltech

Faraday Future


NASA


U.S. AIR FORCE

techstars®

ELEMENTAL
EXCELERATOR

STARBURST

LACI

Global Cleantech 100

hello tomorrow

LACoMotion

SMOGATHON

IEEE N3XT STARS

Bluetech Award


FADEC VERSION B9.4.1 INSTALLED
N643AE
GO AROUND
GO AROUND


KENMORE AIR


MOKULELE
AIRLINES

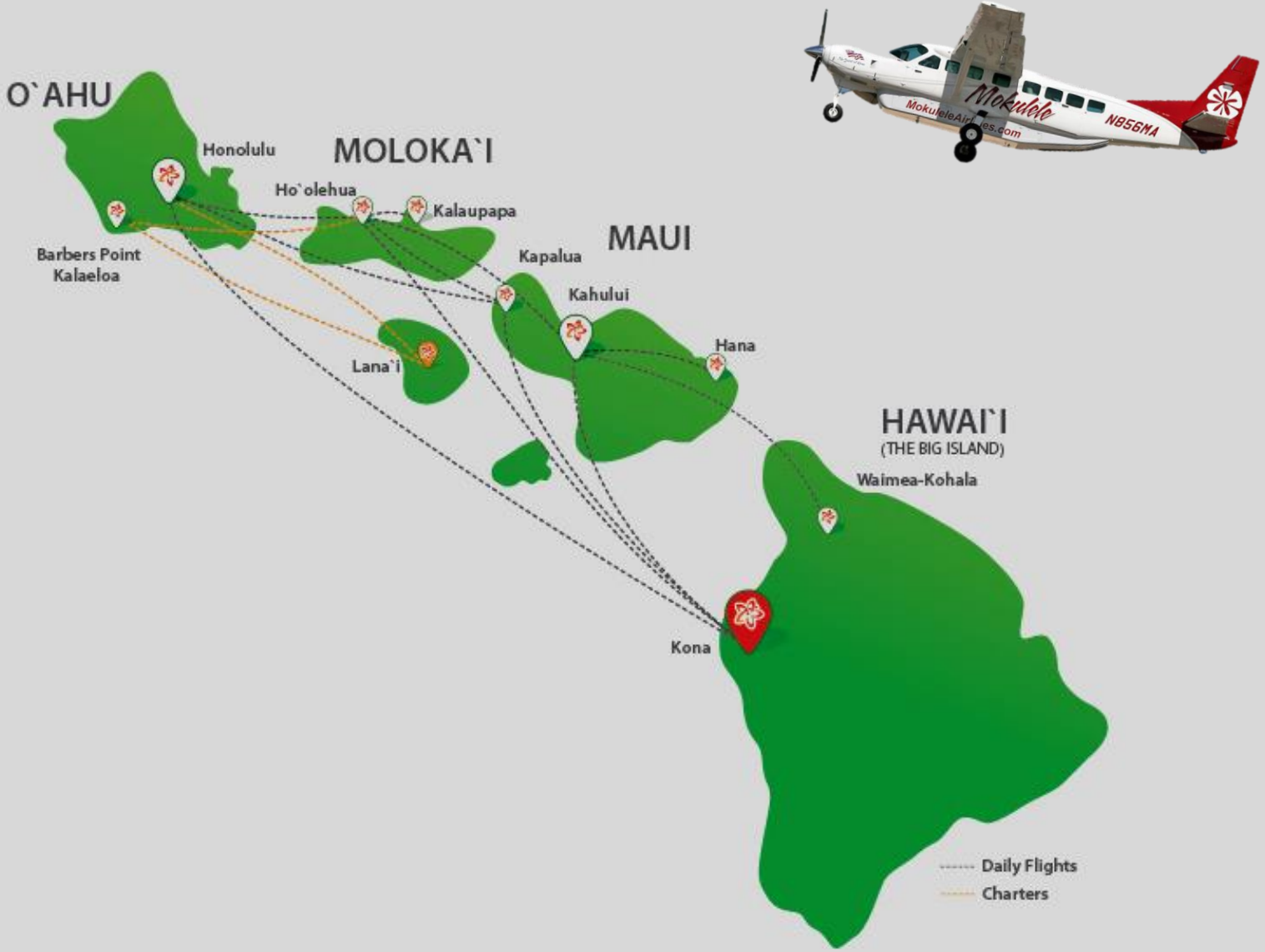

TROPIC
AIR
The Airline of Belize


VIEQUES AIR LINK


SOUTHERN AIRWAYS
EXPRESS


GUERNSEY'S
AIRLINE
aurigny


STAR
Marianas Air



ELEMENTAL
EXCELERATOR

MOKULELE
AIRLINES

The Bottom Line:

Leading The Charge

Kevin Noertker Co-Founder & CEO
kevin@ampaire.com

The Rising Stars

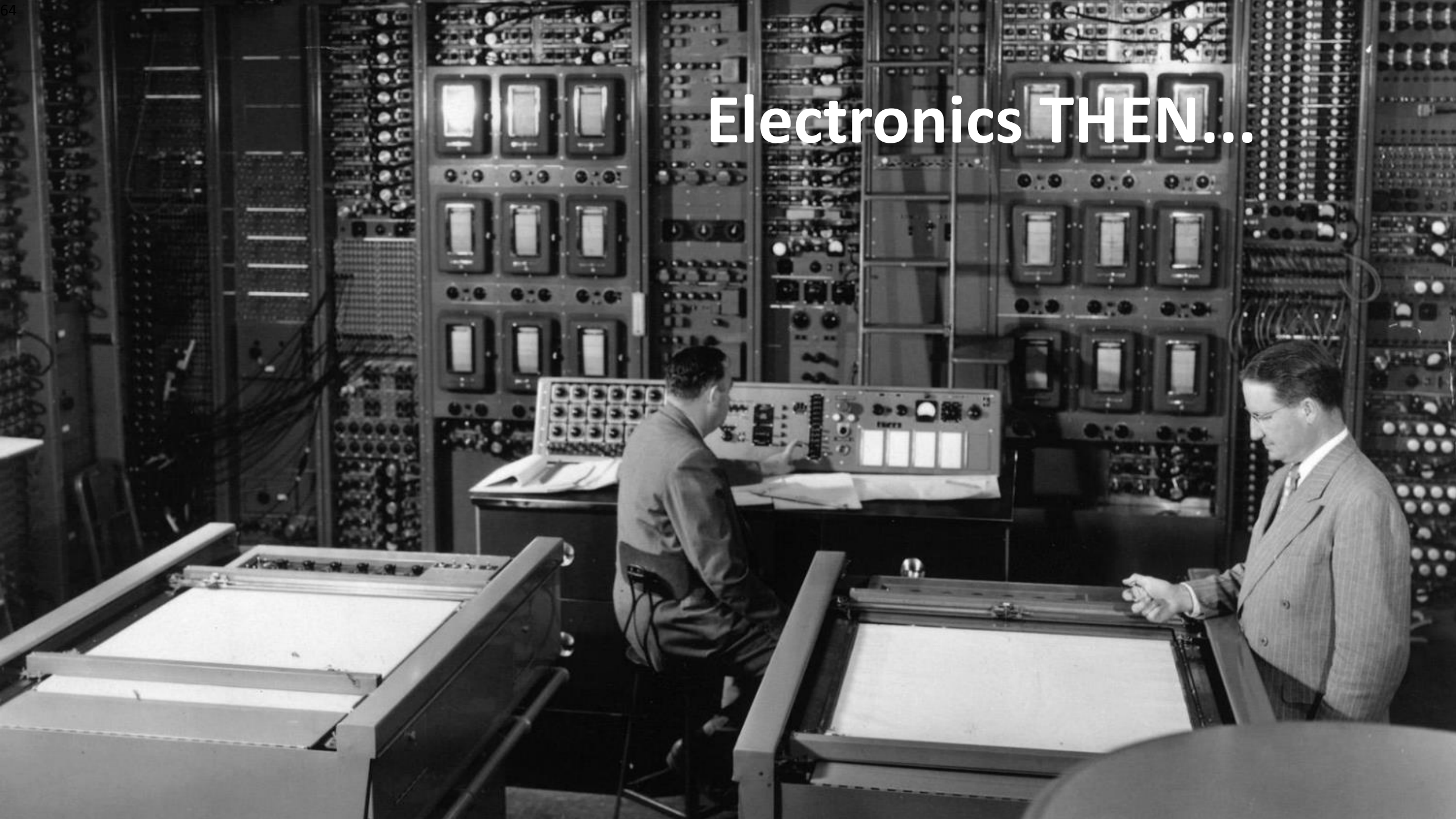
GEORGE PALIKARAS

Founder & CEO, Metamaterial Technologies

Metamaterial Technologies Inc.

Mastering Light

metamaterial.com


Electronics THEN…

Electronics NOW...

Optics has not kept up……

Metamateric Technologies Inc.
Mastering Light

Light

‘Meta’-materials –

from the Greek word to go beyond.

Metamaterial Technologies Inc.
Mastering Light

Metamaterial Technologies mission is to enable every light-using device to manipulate light on demand, at scale and low cost.

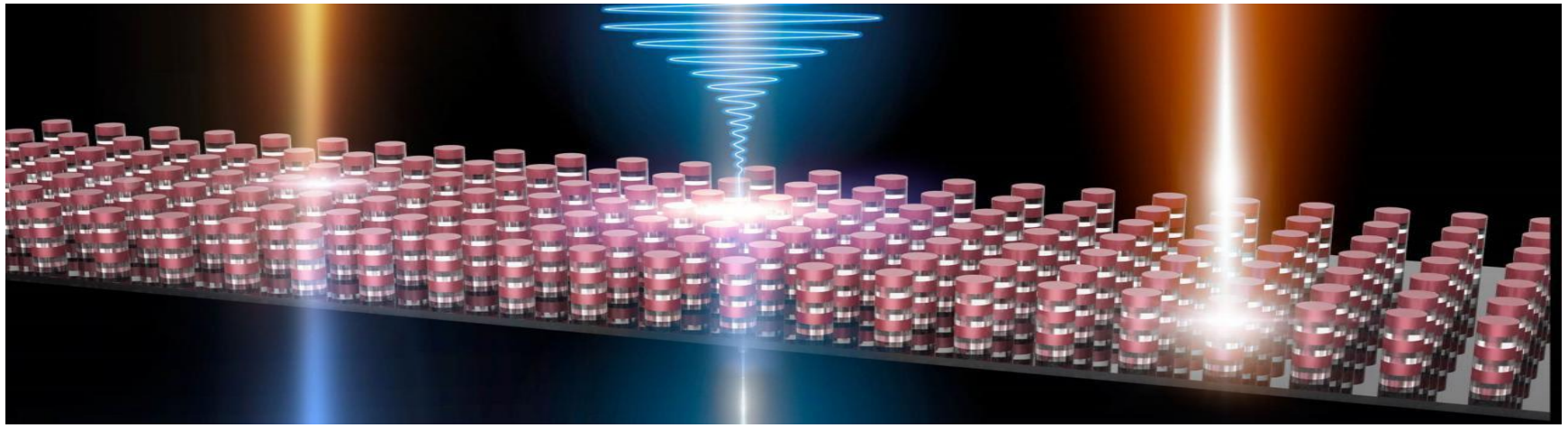
Our vision is to democratize nanotechnology and advanced materials

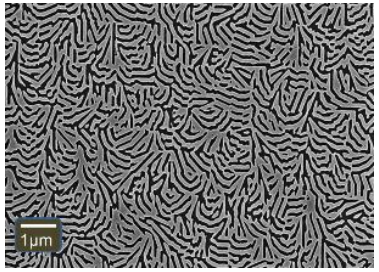
MTI Metamaterial Technologies Inc. Mastering Light

We specialize in Large-Area , High-Performance materials at few $/m^2 that can

block, absorb and enhance light

and can be added to virtually any device.





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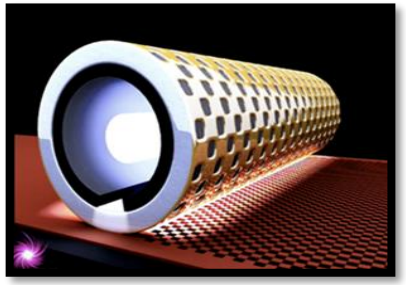

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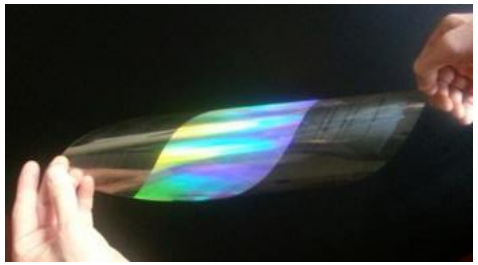
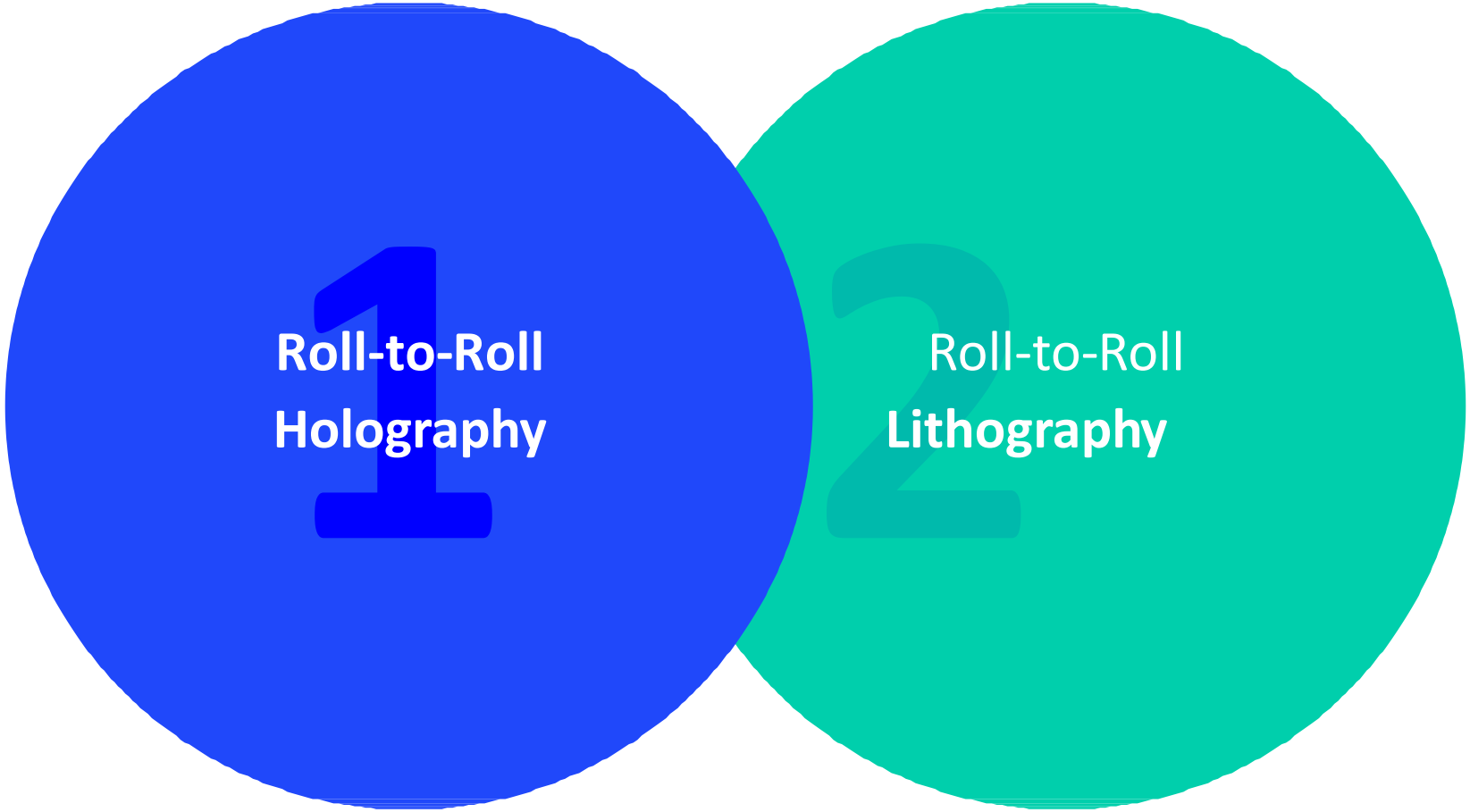


Design & Prototyping Proprietary Tools Scalable & Sustainable Solutions

MTI Metamaterial Technologies Inc. Mastering Light

Disruptive Technology

From 1 million Joules to milli-Joules per cm^2

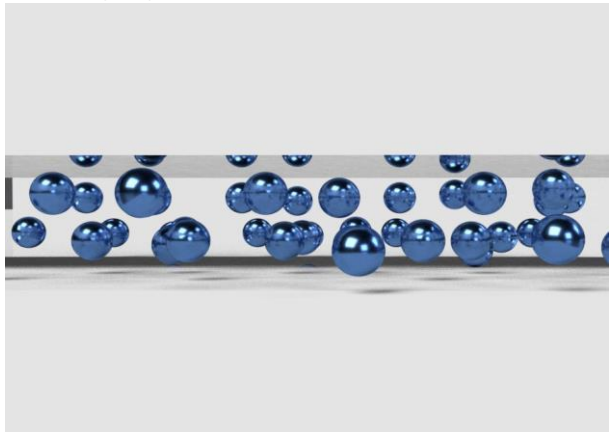


Metamaterial Technologies Inc.
Mastering Light

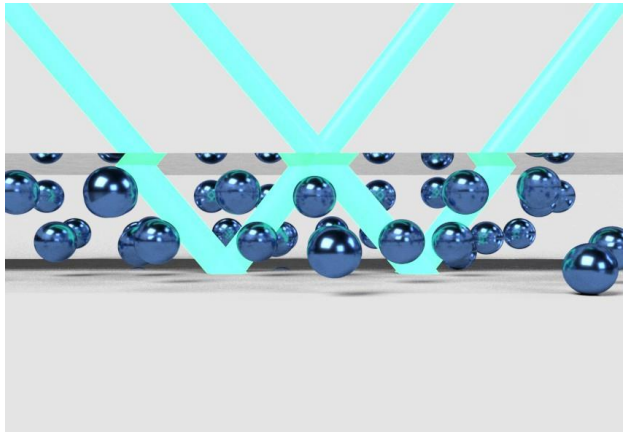
Scanning Holography

1200mm Roll-to-Roll
1 meters / min capable
5nm accuracy

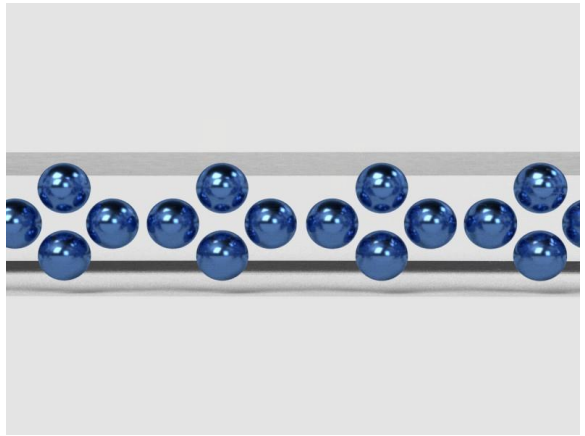
Photopolymer Material Matrix



Holographic Patterning



Re-arranged Molecular Structure

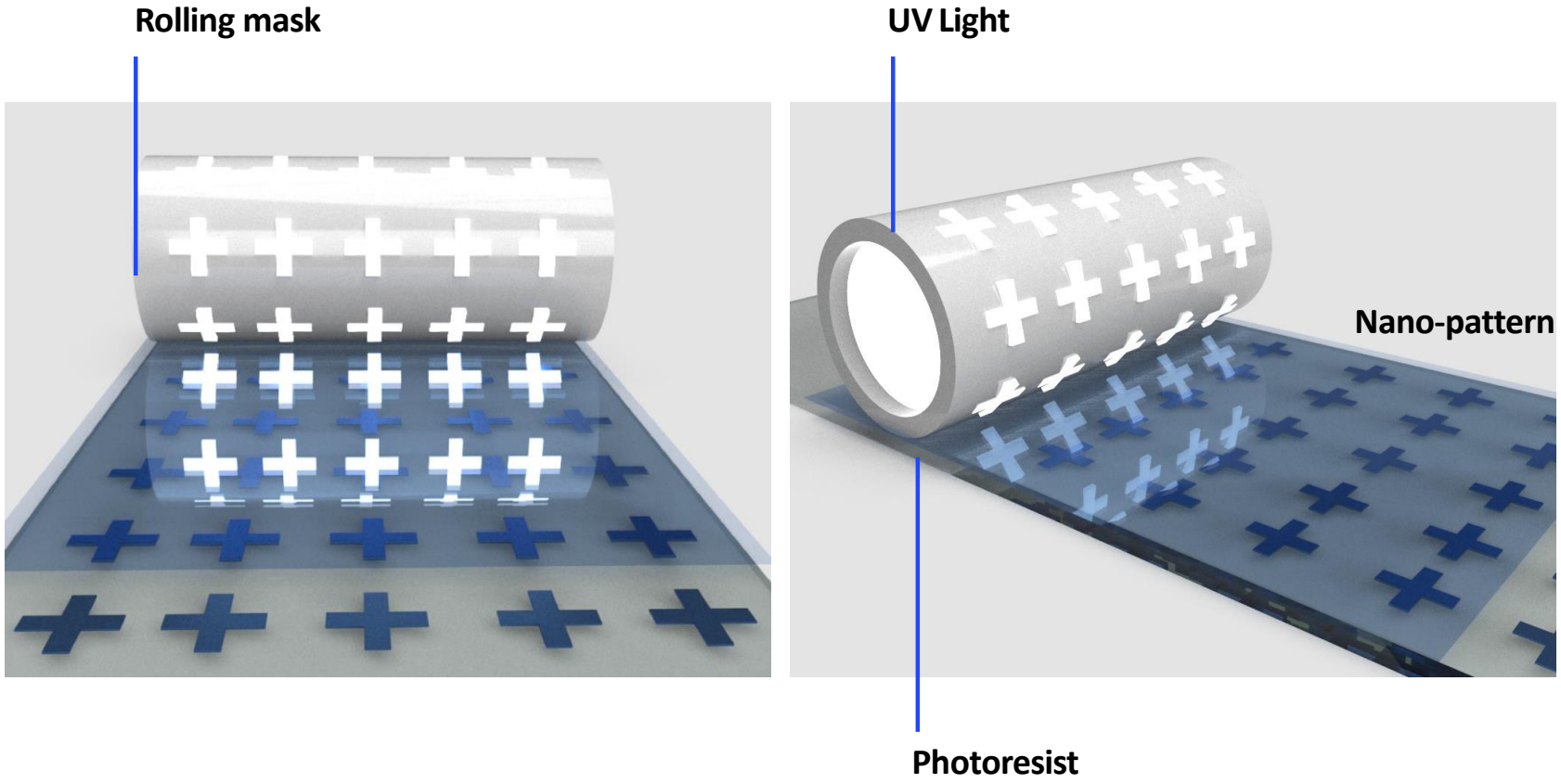


1

Metamateric Technologies Inc.
Mastering Light

Rolling Mask Lithography

150nm
300mm Roll-to-Roll
30 meter / min capable



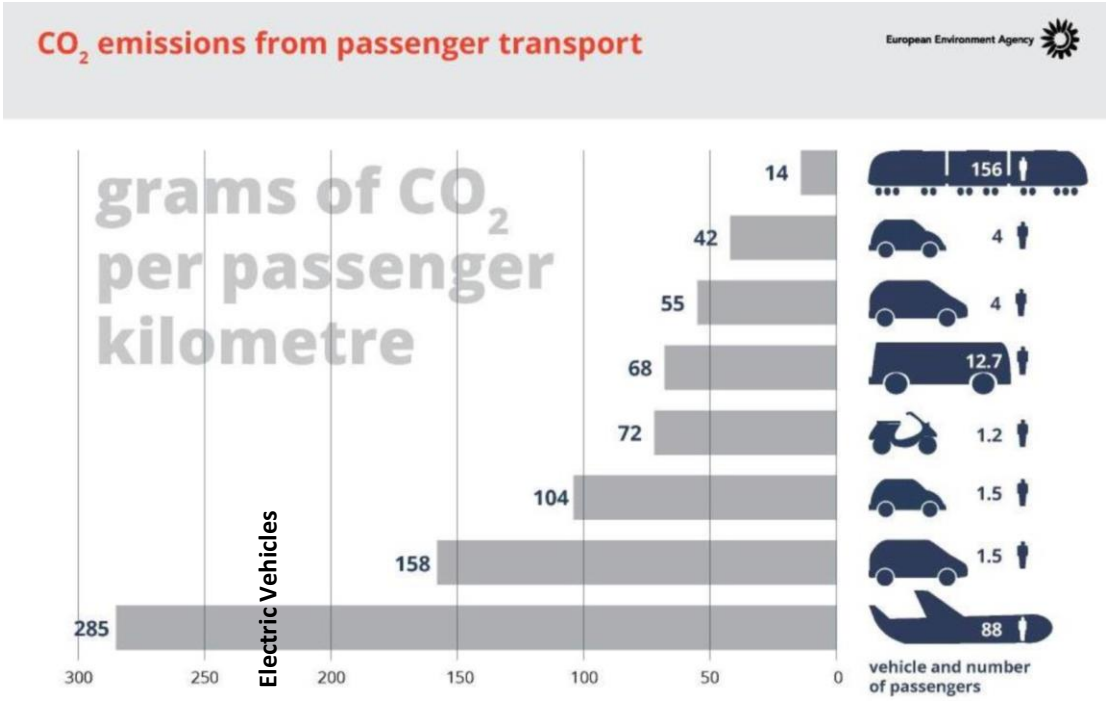
2

The Future of Transport


Toyota Prius


Airbus A320

metaSOLAR

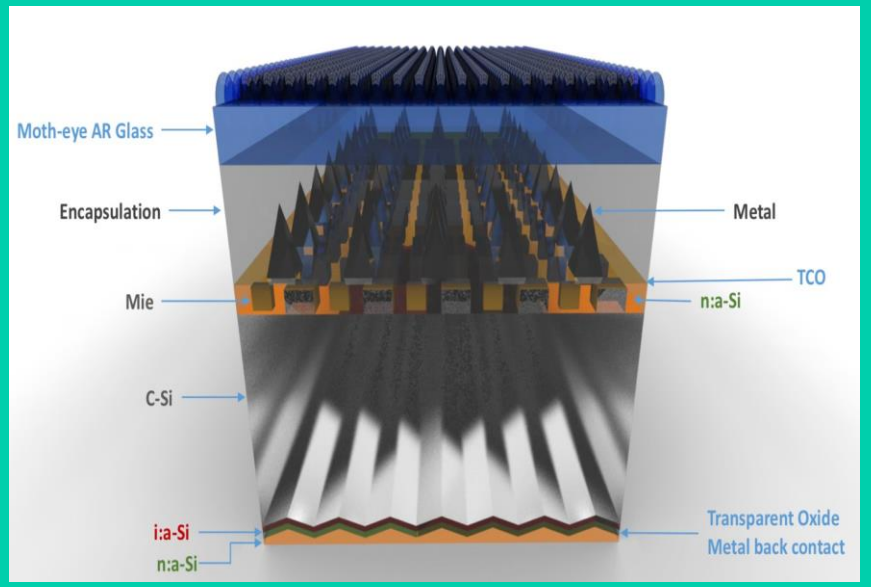


- 1.Solar has low Efficiency to Weight Ratio (Watt/kg)
- 2.Efficiency drops even further without solar tracking
- 3.High-tech efficient solar panels too expensive ($200+/Watt)

MTI Metamaterial Technologies Inc. Mastering Light

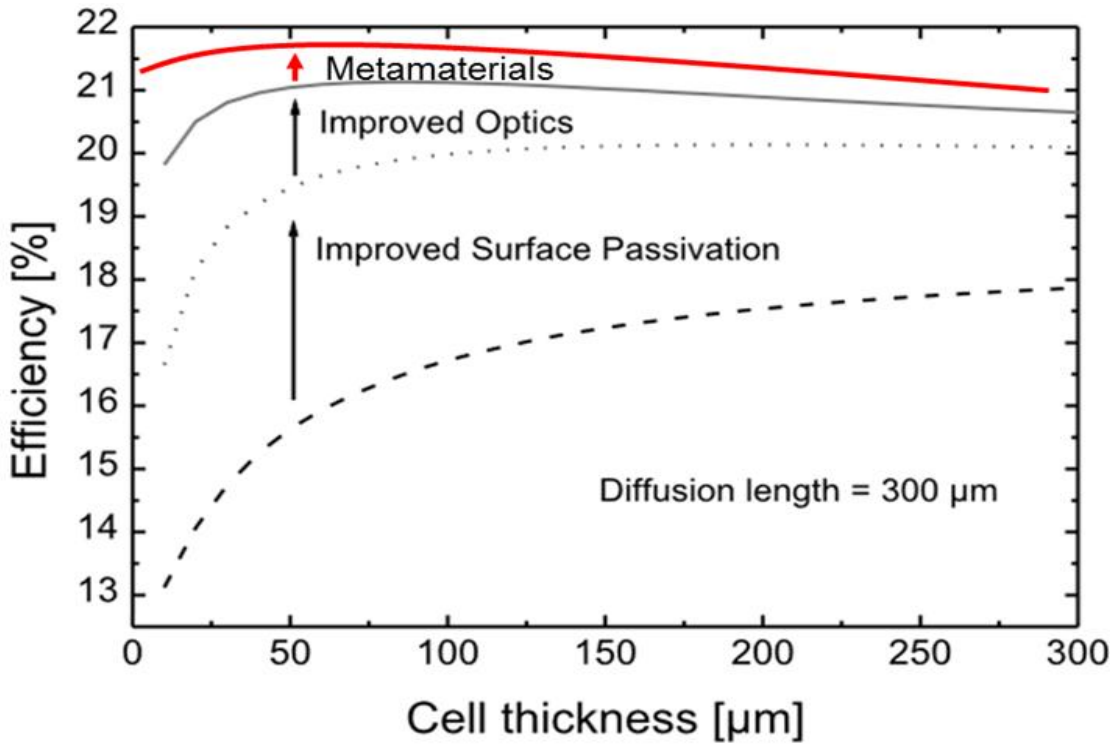
Thin & lightweight –ideal solution for mobility industry
Improves angular absorption – eliminates need for solar tracking systems

metaSOLAR



- 1.Moth-eye structures as anti-reflection coatings on glass
- 2.New transparent metal electrodes to replace ITO
- 3.Mie scatterers for light trapping in active layer

We aim to produce the worlds thinnest Si cells by incorporating metamaterial light trapping coatings to improve light management



Impact	Year	Metasolar Units in active use(m^2)	CO2 Reduction (kilotons / yr)
Hybrid/EV Cars	2025	14 million	2,265
	2035	110 million	17,000
Aviation	2025	0.8 million	93
	2035	1.9 million	220
Residential	2025	2 million	125
	2035	8 million	480

20 Mton/yr Reduction Potential

MTI Metamaterial Technologies Inc. Mastering Light

Partners

LOCKHEED MARTIN

enel Green Power

Caltech

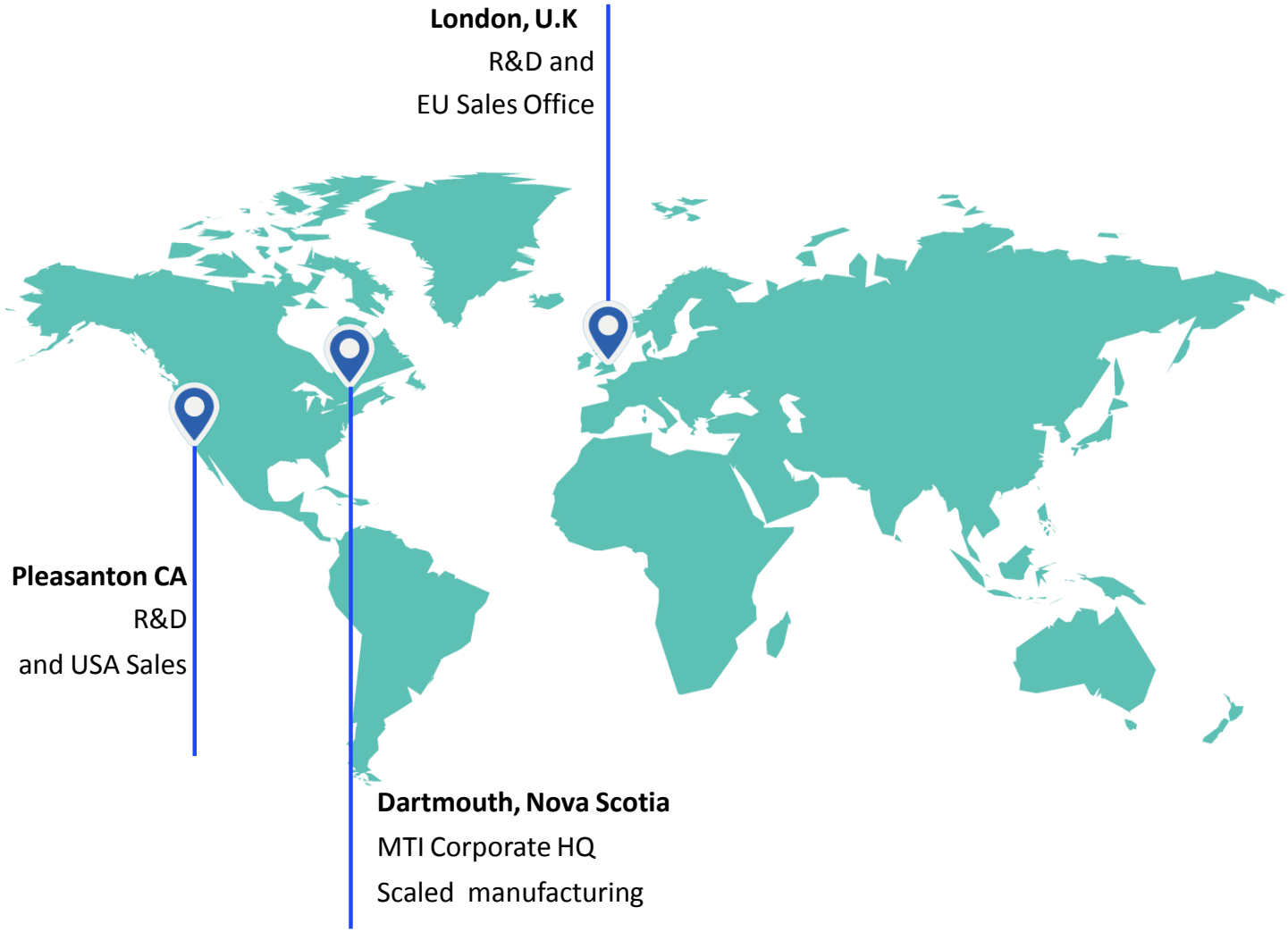
DALHOUSIE UNIVERSITY

Stanford University

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA

NSERC Green Electronics Network

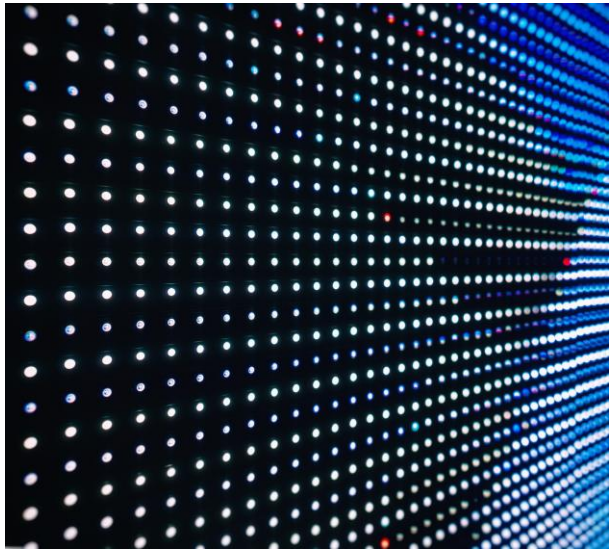
MTI Founded in 2011
Headcount - 46



Metamaterial Technologies Inc.
Mastering Light

Opportunity

$ 1.8 T



MTI Metamaterial Technologies Inc.
Mastering Light

Thank you

metamaterial.com

The Rising Stars

JON SOBEL

CEO, Sight Machine

2019 GLOBAL CLEANTECH100 COMPANY

Produced by Cleantech Group

Sight Machine

Unlocking Sustainability in Manufacturing

Manufacturing: The forgotten sector

A pivotal moment

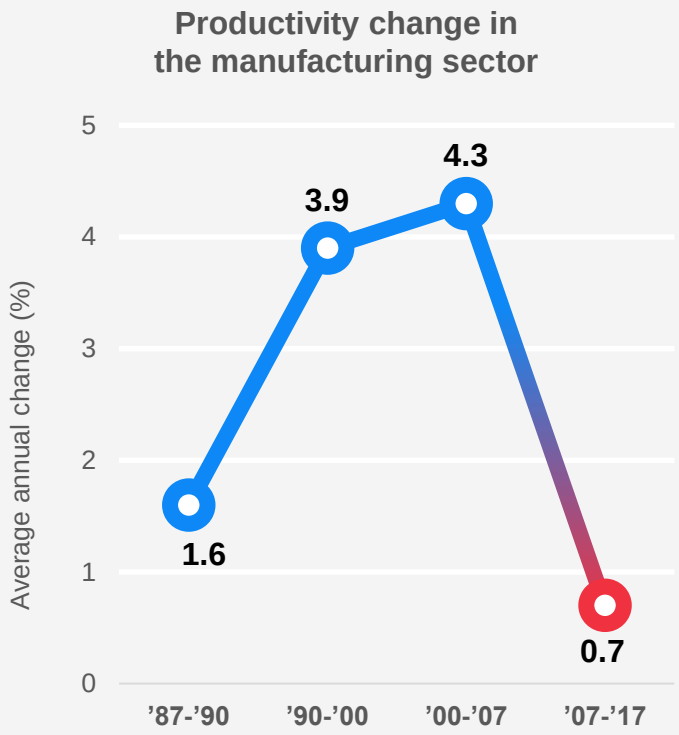
Accelerating growth

16% of Global GDP

$1.33 Multiplier

75% of private sector R&D

Stalled productivity



Source: U.S. Bureau of Labor Statistics

Escalating emissions

22% of GHGs

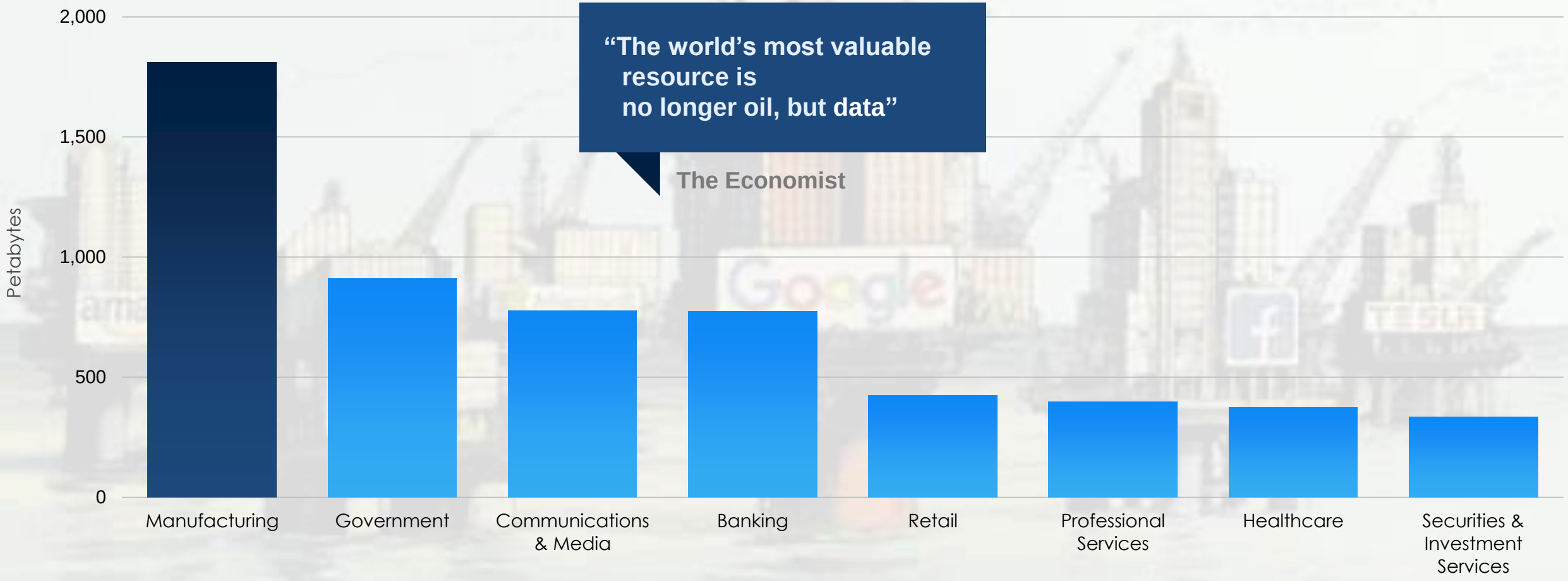
29% when indirect energy is taken into account

In clean energy, "industry has been almost entirely ignored"

Rhodium Group

The most promising path lies in data. Manufacturing, a $15 trillion industry, generates the most data of any sector

If data is oil for the 21st century economy, where would you invest?



Source: Morgan Stanley, IDC, McKinsey Global Institute, World Bank, *The Economist*

But data remains difficult to use

Operators capture machine data manually

Supervisors and production managers lack actionable information

- Not real-time
- Not automated
- Not comprehensive
- No consistency

The challenge is variety

Incumbent data technology handles data volume and velocity well.
Variety remains daunting. Manufacturing is the most extreme environment for variety

The ideal solution is open, agnostic and scalable

Making data useful with the industry's only AI Data Pipeline and Plant Digital Twin

Acquire

Contextualize & Model

Analyze & Visualize

AI Data Pipeline

Input

Collect

Structured

- Windows shares/Excel
- PLCs
- MES/SAP
- Historians/OPC
- Serialization

Unstructured

- Operator entry
- Image/quality

Transform and normalize
Data is restructured

Configure Digital Twin
of plants, lines, assets, products, and processes

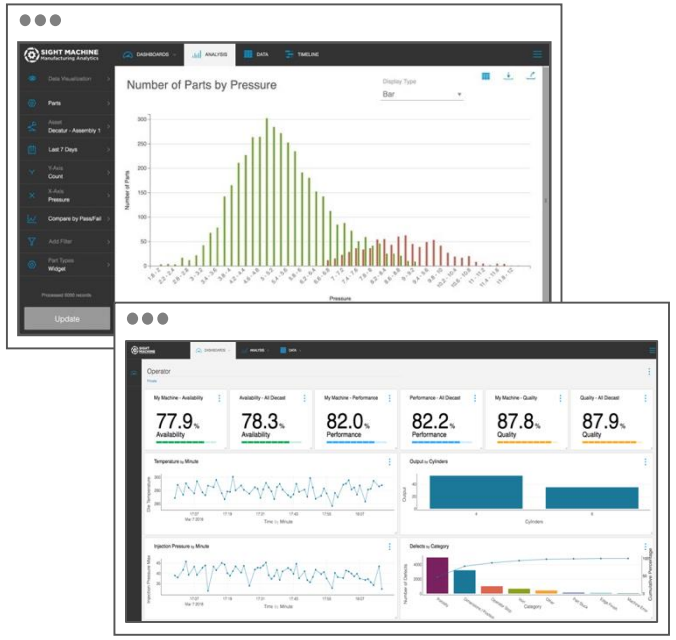
Batch

Defect

Cycle

Line

Machines



Automated and streaming in real-time

Example: Digitizing manufacturing to improve profitability and reduce carbon footprint

Asian chemicals company (zero waste plant)

30 min. reduction
in cycle time achieved in first 2 months

9% improvement
in cycle time achieved in first 2 months

40% increase
in profitability

10-15% decrease
in electricity and water use per unit

Example: Digitizing manufacturing to improve efficiency and reduce carbon footprint

Global materials company

80% cost is energy

Complex process

due to highly varied products, inputs, and conditions

Scale

company seeking to apply same approach to 25+ plants

2%-5% energy reduction

through the use of data analytics

SIGHT MACHINE

The next 10 years: Global scale, every industry

Thank you