

# Enabling the Digital and Energy Transformation

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REC Silicon, CEO

RECSiLICON

MADE IN USA

DOT-SP 14453  
DOT-SP 14977



# Agenda

- › Who We Are
- › Our Process & Technology
- › Our Products, Markets & Applications
- › Energy Trends



# ABOUT US

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# ABOUT US

One of the largest  
Silane producers in  
the world

Nearly 40 years'  
experience in the  
Silicon gas and  
polysilicon industries

We produce high  
purity Silane  
(Signature Silane®)  
and polysilicon

We have one of the  
largest Fluidized Bed  
Reactor (FBR)  
processes in the  
world

USA Based  
Production and  
Development

Publicly listed since  
May 2006 on Oslo  
Stock Exchange



# ABOUT US

## REC Silicon - An Industry Leader



Whether supplied as a gas, gas derivatives, or used internally to manufacture ultra-pure polysilicon, our Signature Silane® is increasingly demanded for leading-edge power devices, big data, nano-electronics, communication devices, and renewable energy industries.

**Signature Silane® is also what sets us apart.**

# ABOUT US

## Global Presence – History



Year	Announcement
1984	Moses Lake facility, (Silane I & Silicon I), commissioned by Union Carbide
1990	Purchased by Komatsu Ltd., creating Advanced Silicon Materials (ASiMI)
1998	Butte Plant start-up (Silane II and Silicon II)
2002	Moses Lake plant becomes Solar Grade Silicon LLC owned by REC/ASiMI
2005	ASiMI purchased by REC, creating REC Silicon
2009	Silane III, Silicon III (FBR) commercial reactor in Moses Lake
2010	Start-up of Silane IV in Moses Lake
2015	Joint Venture breaks ground in Yulin China
2019	Moses Lake plant production curtailed
2022	Restarting of Moses Lake

# OUR PROCESS & TECHNOLOGY

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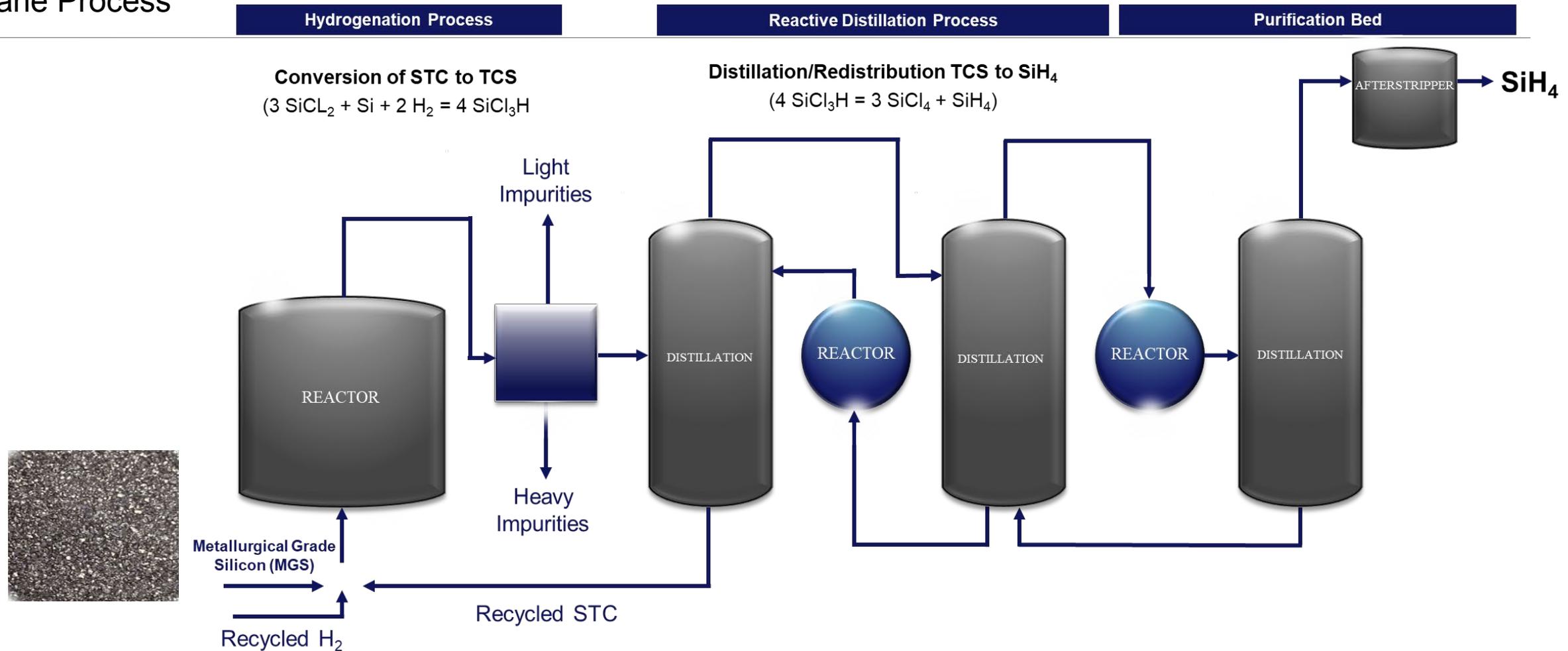
# OUR TECHNOLOGY

## SIGNATURE SILANE®

At the core of REC Silicon's technology is our molecule,  $\text{SiH}_4$ , and the safe, sustainable best practices to produce it.

# OUR TECHNOLOGY

## Silane Process

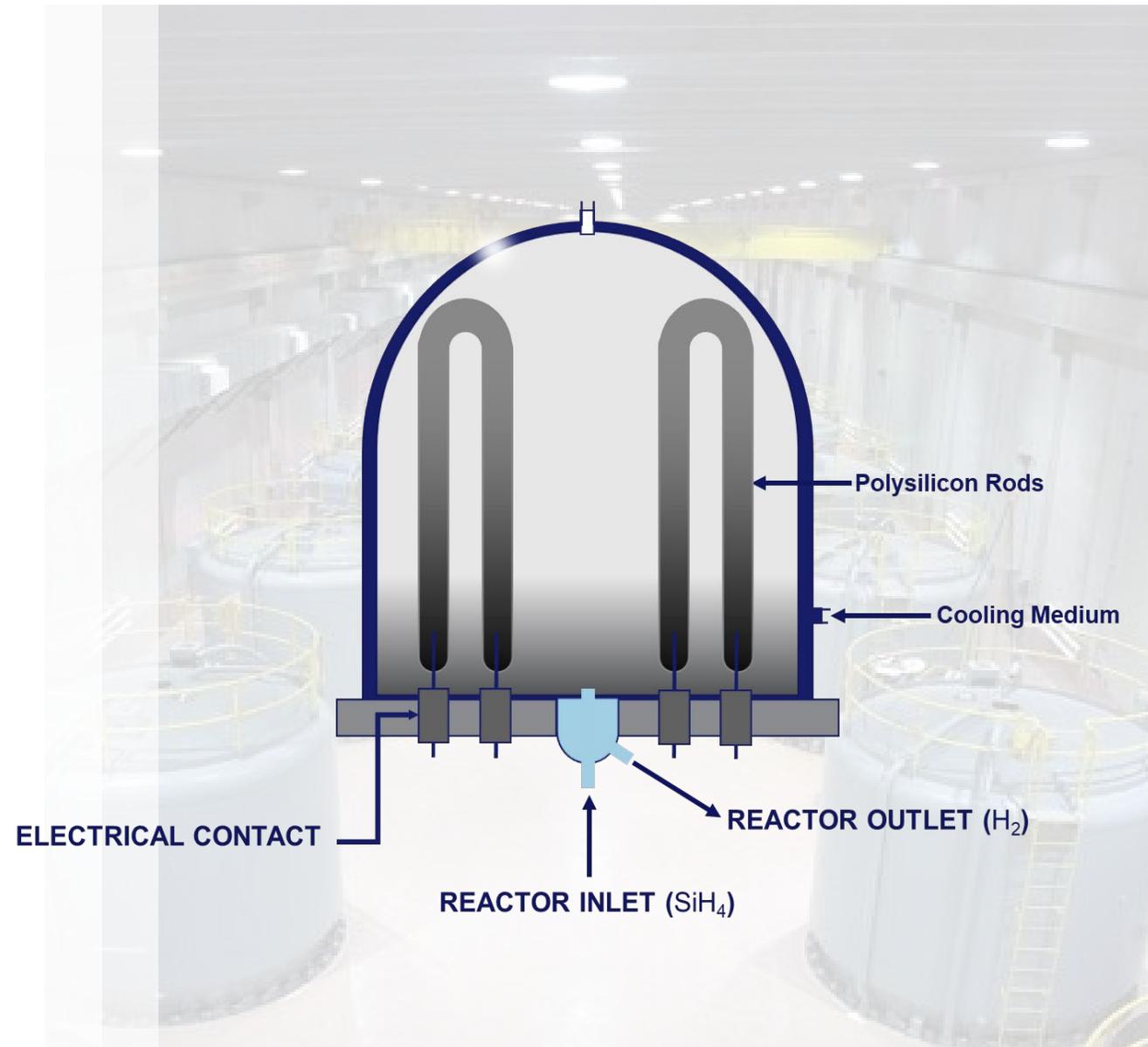


# OUR TECHNOLOGY

## Siemens Processes

- › Based on the decomposition of Signature Silane® ( $\text{SiH}_4$ ):
  - Heating until the ultra-pure elemental silicon and hydrogen are separated.
  - Silicon seed rods are heated, and the elemental silicon is deposited.
  - Hydrogen is removed and recycled.

**Resulting high-purity product is ideal for Float Zone (FZ) and Czochralski (CZ) polysilicon applications.**

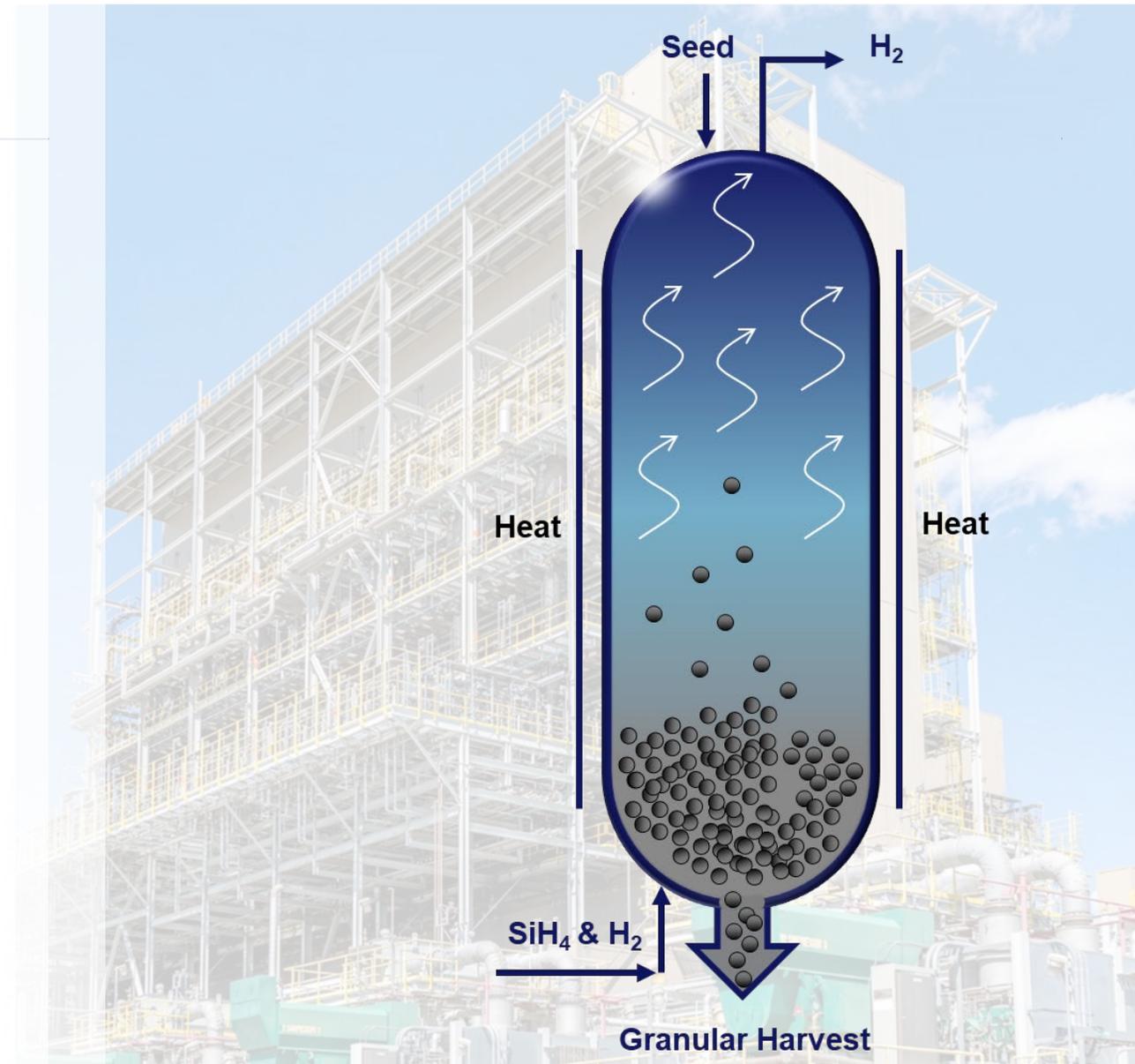


# OUR TECHNOLOGY

## Fluidized Bed Reactor (FBR) Processes

- › FBR uses seed granules continuously fed into a chamber with heated silane.
- › Circulation of gas causes the seed granules to flow like a liquid as silane breaks down and deposits silicon layers on the granules.
  - Hydrogen is removed and recycled.
- › Over time the granules grow larger, heavier, and finish out the bottom.
- › Energy consumption is reduced 80-90% per comparative Siemens-silicon while producing more silicon per cubic meter of reactor space.

**Smallest carbon footprint in the industry being fueled by hydroelectric power at the Moses Lake facility.**



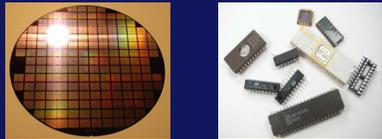
# PRODUCTS, MARKETS & APPLICATIONS

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## Silicon Gas and Polysilicon Markets

(Silane All Packages, DCS, MCS, Disilane)

### Semiconductor



### Display (TFT)



### Photovoltaic



### Other

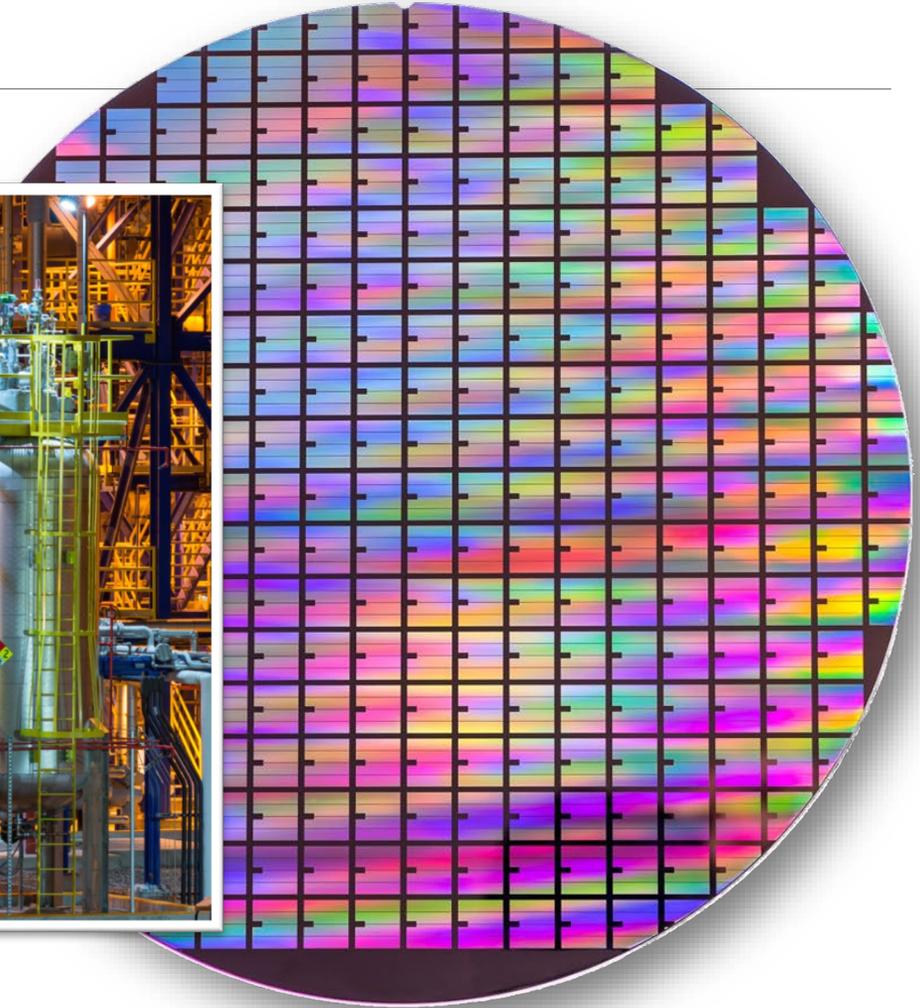
LED  
III-V Devices  
Glass  
Silicon Anodes  
Semi Wafer Backside/EPI  
SiC Deposition



# SPECIALTY GASES

REC Silicon is also the world leader in differentiated specialty gases

- › **Dichlorosilane** (DCS, or  $\text{SiH}_2\text{Cl}_2$ ) used in memory chip manufacturing and logic device production
- › **Monochlorosilane** (MCS or  $\text{SiH}_3\text{Cl}$ ) used to synthesize advanced precursors
- › **Disilane** ( $\text{Si}_2\text{H}_6$ ) for device production in strained silicon, 45nm transistors, thin Film PV, and flexible electronics and displays



# GLOBAL DISTRIBUTION IS ANOTHER ASPECT WHERE WE DOMINATE

Our Heritage – Signature Silane® is what sets REC Silicon apart

- › Signature Silane® as our core feedstock produces the highest quality products needed for our product lines of:
  - Specialty gases
  - Electronic grade polysilicon
  - Solar grade polysilicon



125 kg



1000 kg



3000 kg



4300 kg



6000 kg

- › We own the largest global fleet of silane containers from cylinders to 40' modules

**From everyday technologies of solar cells, smartphones, and computer chips, to cutting edge components used in 5G communications, Signature Silane® is the material of choice.**

# ELECTRONIC GRADE POLYSILICON



Our electronic grade ISO 9001-2015 certified polysilicon businesses provide a variety of form factors for uses in high-tech energy and electronics industries.

## › Float Zone (FZ)

- FZ-based devices are used in motor control and power conversion processes for hybrid and electric vehicles, wind energy, and high voltage transmission, 5G communications, high-speed trains, IoT (internet of things), and big data.



## › Czochralski (CZ)

- This form of electronic grade polysilicon is principally used in manufacturing of 12' semiconductor wafers used in memory processors, optics, and micro electromechanical systems (MEMS).



# GRANULAR SOLAR GRADE POLYSILICON

The most efficient technology to make polysilicon

- › Our granular polysilicon, NextSi®, when blended with solar grade chunk polysilicon:
  - Enhances efficiency of the ingot manufacturing process by increasing the weight and yield of the ingot
  - Reduces process cycle times
  - Ready-to-use

**NextSi® is ideal for multicrystalline and monocrystalline solar ingot and wafer production in the manufacturing of solar modules.**

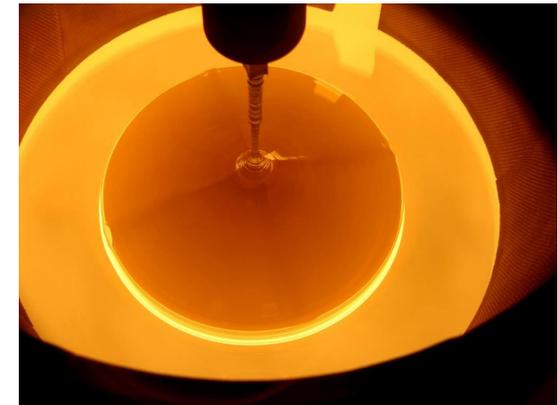
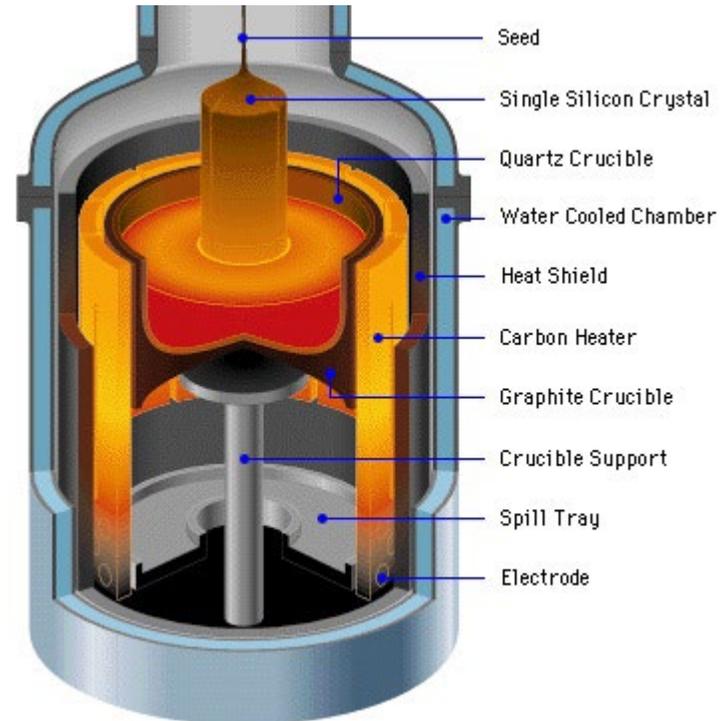
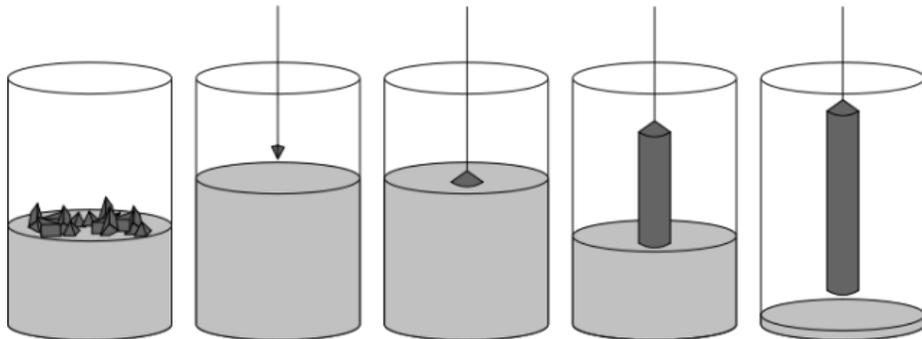


# POLYSILICON TECHNOLOGY

## Czochralski (CZ) Ingot Crystallization Process

### › Applications

- Semiconductor
- Solar Energy

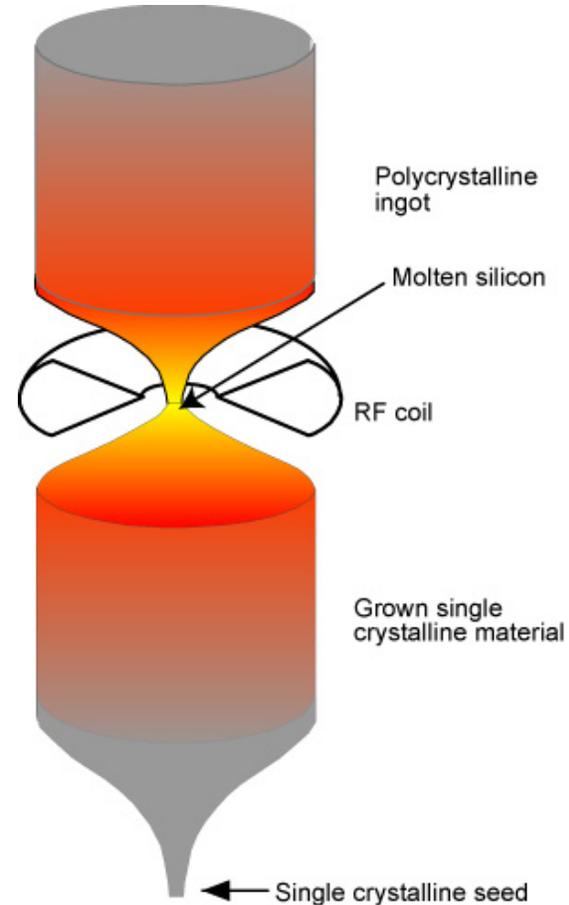
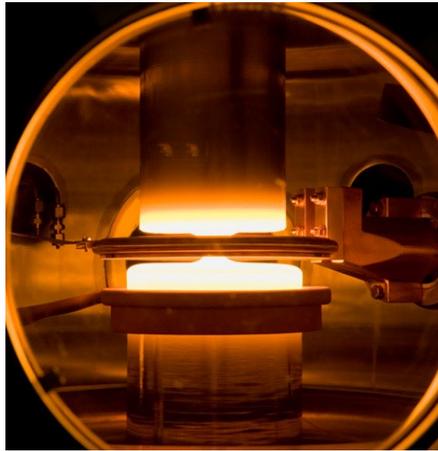


# FLOAT ZONE TECHNOLOGY

## FZ Crystallization Process

### › Applications

- High power electronics
- SCR
- Ships
- Locomotion



# EXAMPLES OF SEMICONDUCTOR APPLICATION



- › The growing wave of semiconductor applications in vehicles, including:
- Security/safety
  - LED lighting
  - Navigation
  - Entertainment
  - Collision avoidance radar
  - Battery management and engine controls



SCR from Powerex and Valve Hall at HVDC Station



Tesla Model S Motor Controller  
84 FZ IGBT's

Source: World Semiconductor Trade Statistics (WSTS), 2018 Annual End-Use Survey, IC Insights

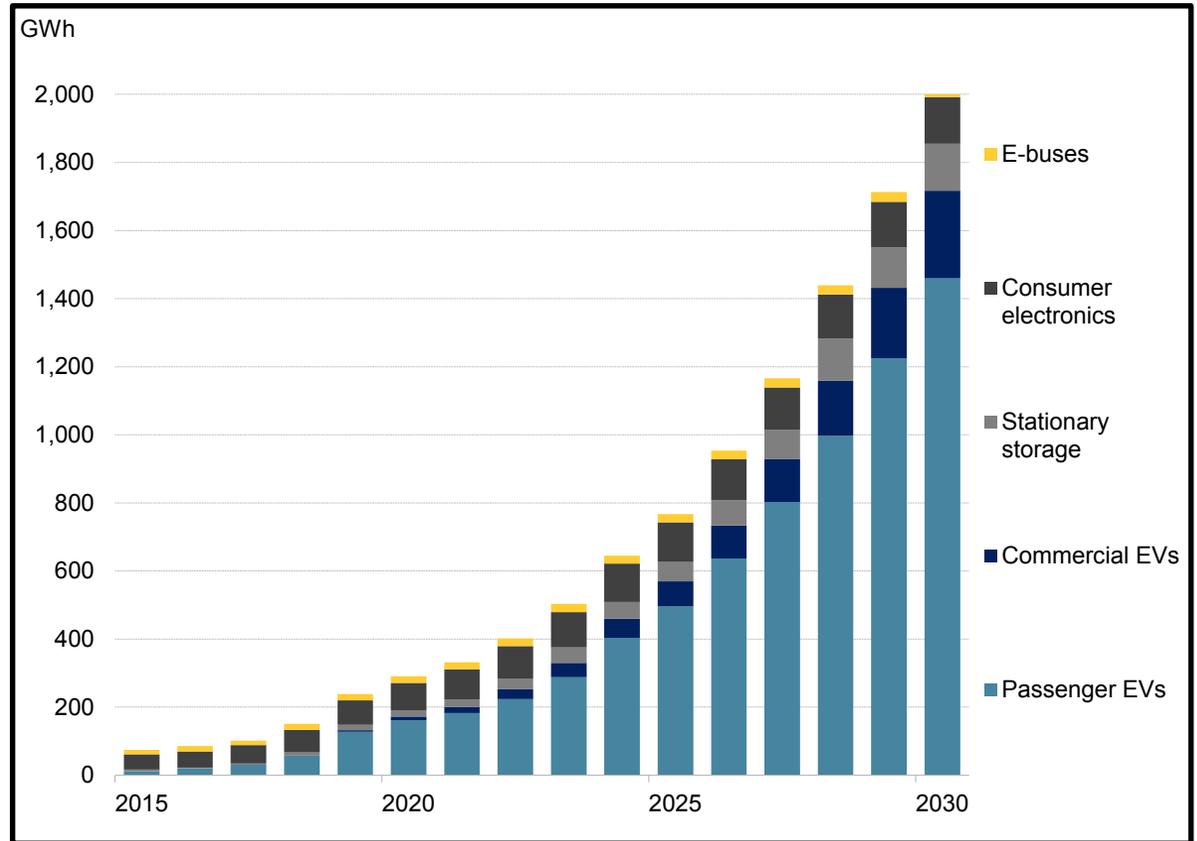
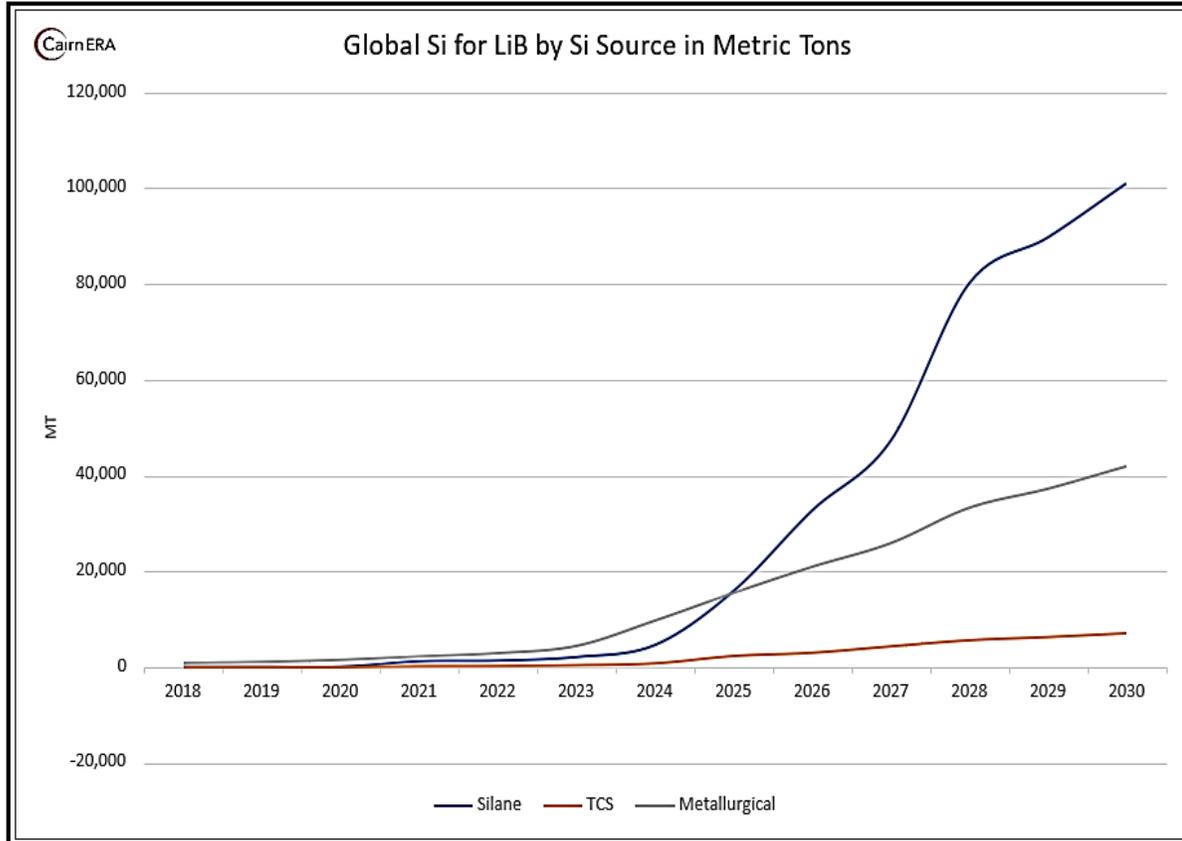
# LITHIUM SILICON EMERGING AS THE NEW BATTERY TECHNOLOGY NODE FOR THE MID-2020S

Expect three broad battery material technology waves in passenger auto EVs in 2020s

	Wave 0 <i>Since 2015</i>	Wave 1 <i>Early-2020s</i>	Wave 2 <i>Mid-2020s</i>	Wave 3 <i>Late-2020s</i>
Anode	Graphite-based	Silicon-based		Li-metal
Electrolyte	Liquid (e.g. LiPF <sub>4</sub> )		Solid (e.g. Polymer- or Ceramic-based)	
Cathode		Nickel- & cobalt-based		Sulfur-based
Energy Density (est.)	1x	1.2x	1.5x	Over 2x

# NEXT GEN LITHIUM-ION BATTERIES REQUIRE SILICON ANODES

Silane could be the preferred Silicon source



Source: BNEF - Long-Term Electric Vehicle Outlook 2019 May 2019

# SILANE: FEEDSTOCK FOR THE ENERGY TRANSITION

## SILANE

### BATTERY VALUE CHAIN

#### Silicon Anodes May Drive Silane Market Expansion

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- Sole supplier of pure silane in US
- Co-Location is the best supply mode at large volumes
- Process is self contained and has wide flexibility in location

**Will it take off?**

### SEMICONDUCTOR

#### Proven Global Leader

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- Largest merchant supplier of Silane globally
- Growing portfolio of deposition gases
- 1 of 2 suppliers globally of High-purity FZ polysilicon

**USA Growth strong**

### SOLAR VALUE CHAIN

#### Established Footprint to Capture Solar Market Upside

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- Moses Lake FBR Poly: ~16,000MT
- Restart of capacity in late Q3/Q4 2023
- More capacity is needed to meet re-shoring ambition

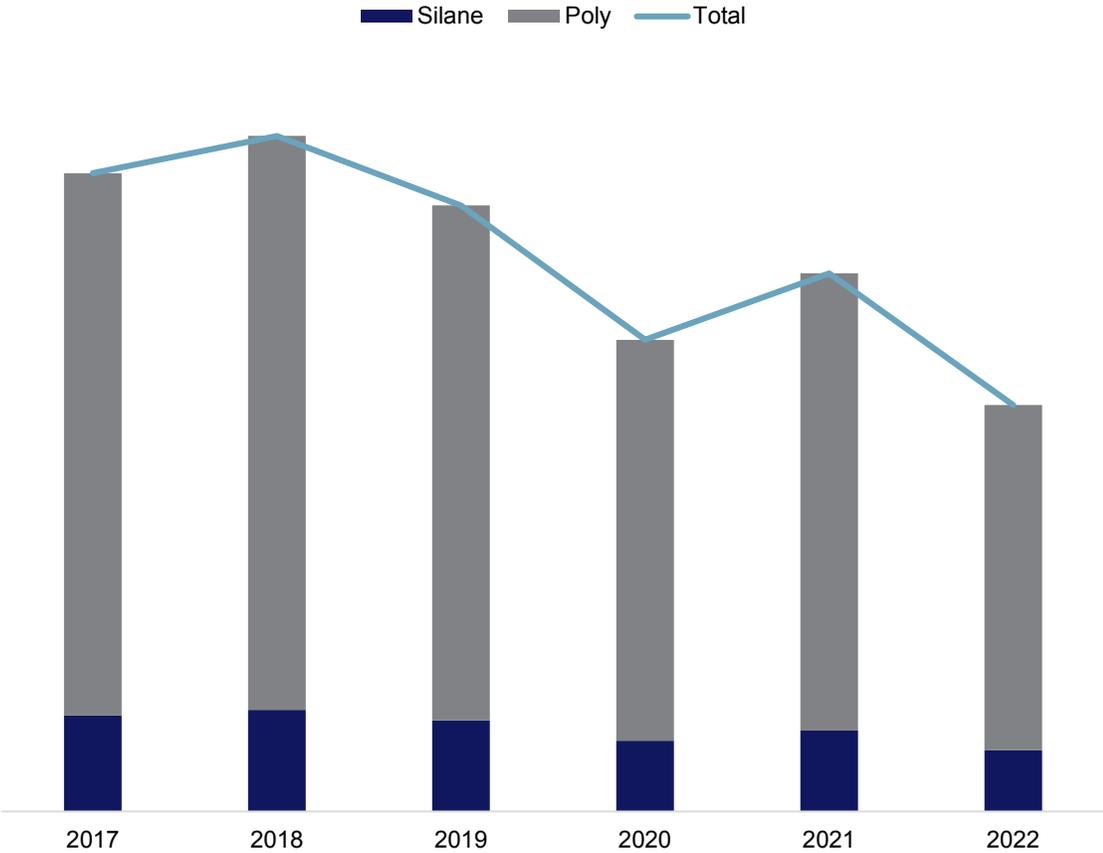
**Low energy intensity**

# ENERGY TRENDS

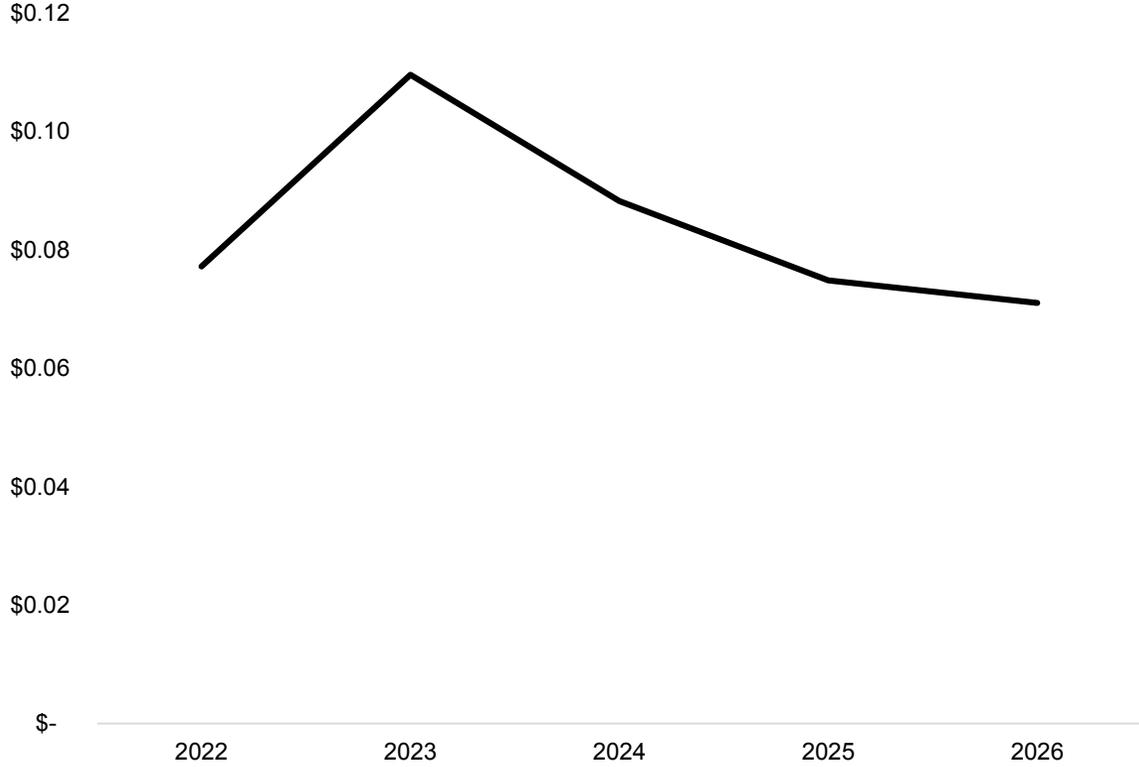
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# ELECTRICITY CONSUMPTION TREND

We need to turn the trend around...

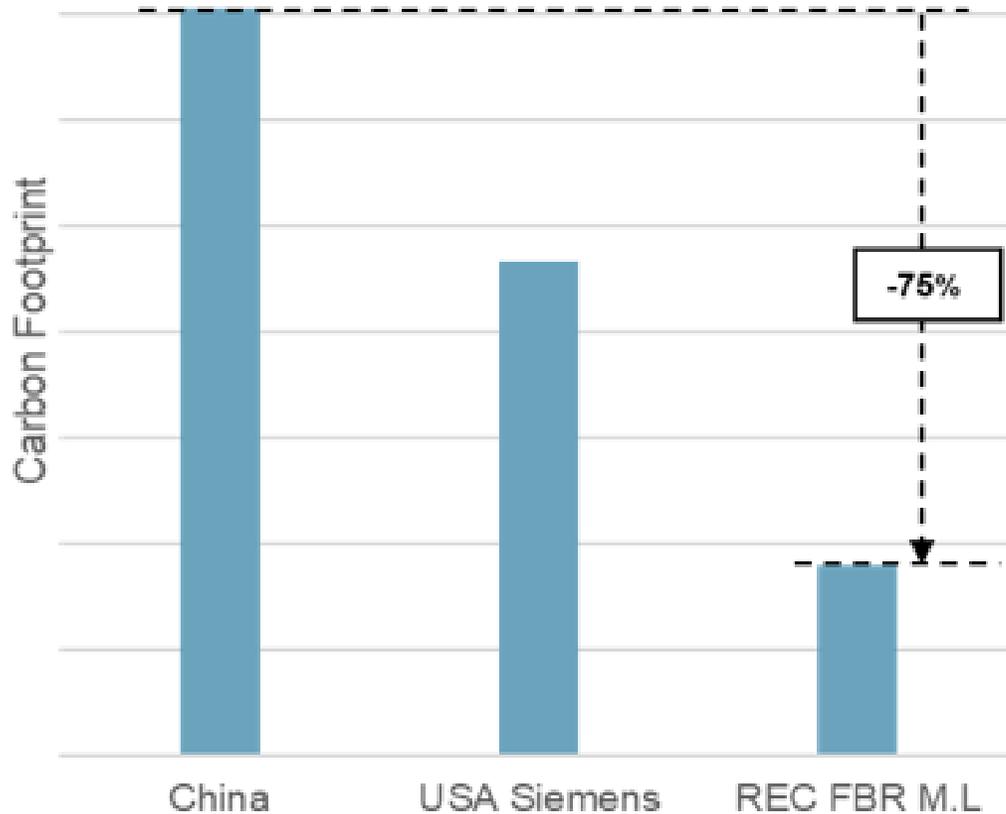


## Mid-C Forward Pricing



# FLUID BED REACTOR VS. SIEMENS REACTOR

Poly Silicon Carbon Footprint Using French CRE Standard



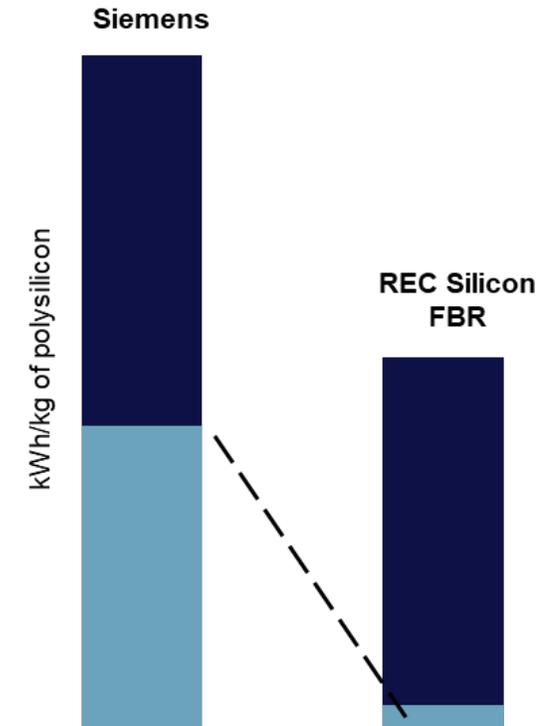
## › FBR vs. Siemens:

- consumes about 50% the total energy
- has the lowest carbon footprint
- requires about 1/3 the labor force

› The result is lower OPEX compared to Siemens

Energy Consumption Comparison

- Feed gas, utilities, recovery, waste treatment
- Polysilicon CVD (Includes gas recirculation for FBR, heat recovery for Siemens)



RECSiLICON

**Thank You!**

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[www.recsilicon.com](http://www.recsilicon.com)

