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ENERGY I-CORPS
U.S. Department Of Energy

Sandia National Laboratories

Regenerable catalysts

Formerly known as: solar dry reforming of methane

61 *Interviews completed*

Energy I-Corps

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NNSA U.S. DEPARTMENT OF ENERGY

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Our progression from dry reforming to emission catalysis

Dry reform methane instead of flaring

> Without strict regulations, flaring will continue
>
> *- retired Shell employee*

> Dry reforming market share will remain small
>
> *- Linde*

Upgrade methane from anaerobic digestion

> CA market pays 10x for green natural gas
>
> *- R Cubed*

> Methane from AD isn't wasted or emitted
>
> *- Living Art Systems*

Palladium-free diesel catalytic converters

> Meeting regulations while minimizing cost is the game
>
> *- General Motors*

Provide regenerable catalyst for chemical production

> Processes haven't changed, the catalyst does
>
> *- Eastman Chemical*

> Cost of catalyst is negligible
>
> *- Dow Chemical*

Value Propositions for Regenerable Catalyst

We **provide a low-cost emission treatment catalyst** for **diesel vehicle manufacturers** through a viable **palladium-free catalyst design that meets strict emission regulations.**

Value propositions for our catalyst

Lowering catalyst cost

Reducing price volatility

Reducing precious metal use

Customer segments

Automotive manufacturers

Diesel truck manufacturers

Off-road diesel vehicle manufacturers

Value Proposition Canvas

Product

Benefits

- Reduced catalyst cost
- Reduced price volatility
- Reduced dependence on strained supply chains

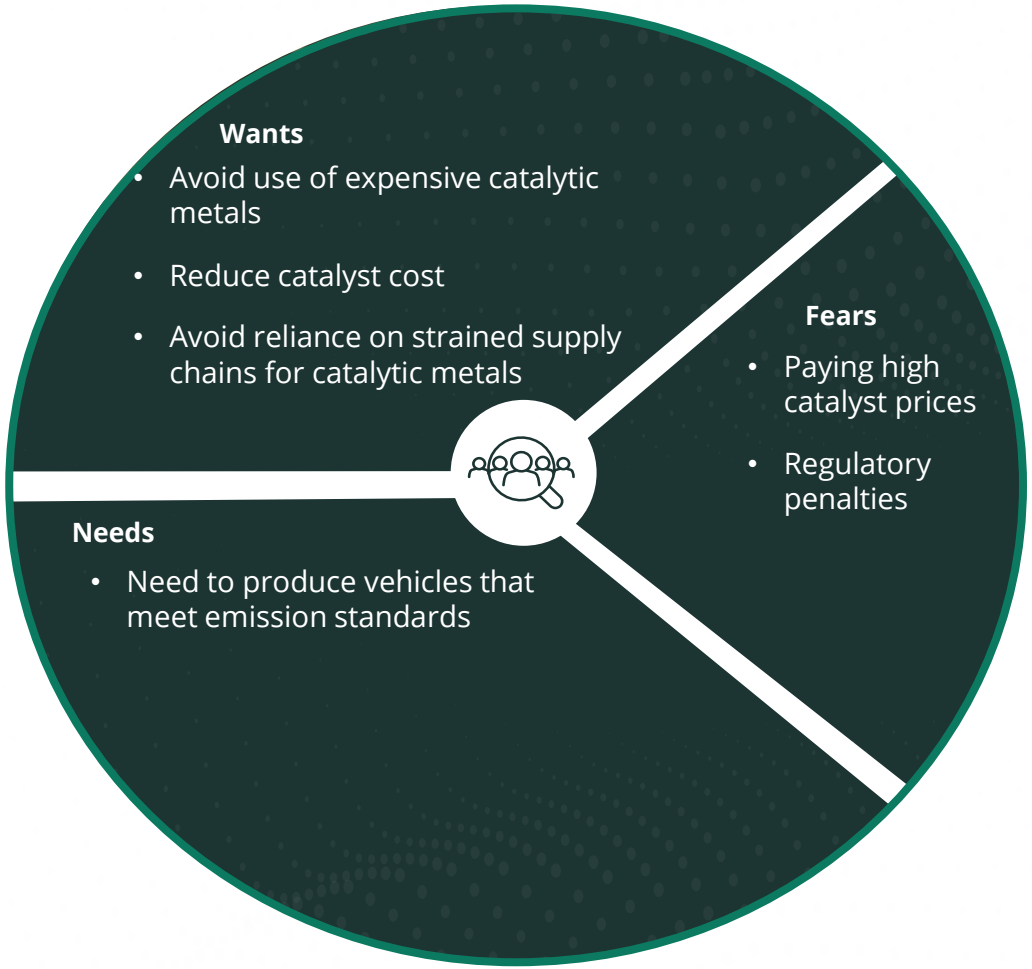
Experience

- Meeting stricter emission regulations
- Better product reliability
- Improved supply chain surety

Features

- Palladium-free catalyst formulation
- Inherent catalyst self-regeneration mechanism preventing degradation

Customer



Product
Palladium-free diesel vehicle emission catalyst which structurally regenerates

Ideal Customer
Diesel engine manufacturers and operators looking to lower catalyst cost

Substitutes
Increasing catalyst content of other PGMs to make up for catalyst degradation or unavailability

Customer discovery findings

Assumptions Confirmed

Lowering catalyst cost is important

Reducing precious metal use is important

Use of rare precious metals may create supply chain issues

Business Model Canvas

Key Partners

- Catalyst manufacturers
- ➢R&D MGMT
- ➢Customer catalysis dept.
- ➢Process release engineer
- ➢IP, licensing dept.

Key Activities

- Partner development with catalyst manufacturers
- Technical discussions
- Scale up and validation runs
- Marketing

Key Resources

- Lab expertise in catalysis
- Testing expertise
- IP

Value Propositions

- Providing a lower-cost diesel oxidation, palladium-free, catalyst which meets strict emission standards

Customer Relationships

- CRADAs
- Technical discussions
- Catalyst validation

Channels

- Conferences
- Publications
- Existing customer relationships

Customer Segments

- Diesel semi truck manufacturers
- Construction vehicle manufacturers
- Agricultural vehicle manufacturers

Cost Structure

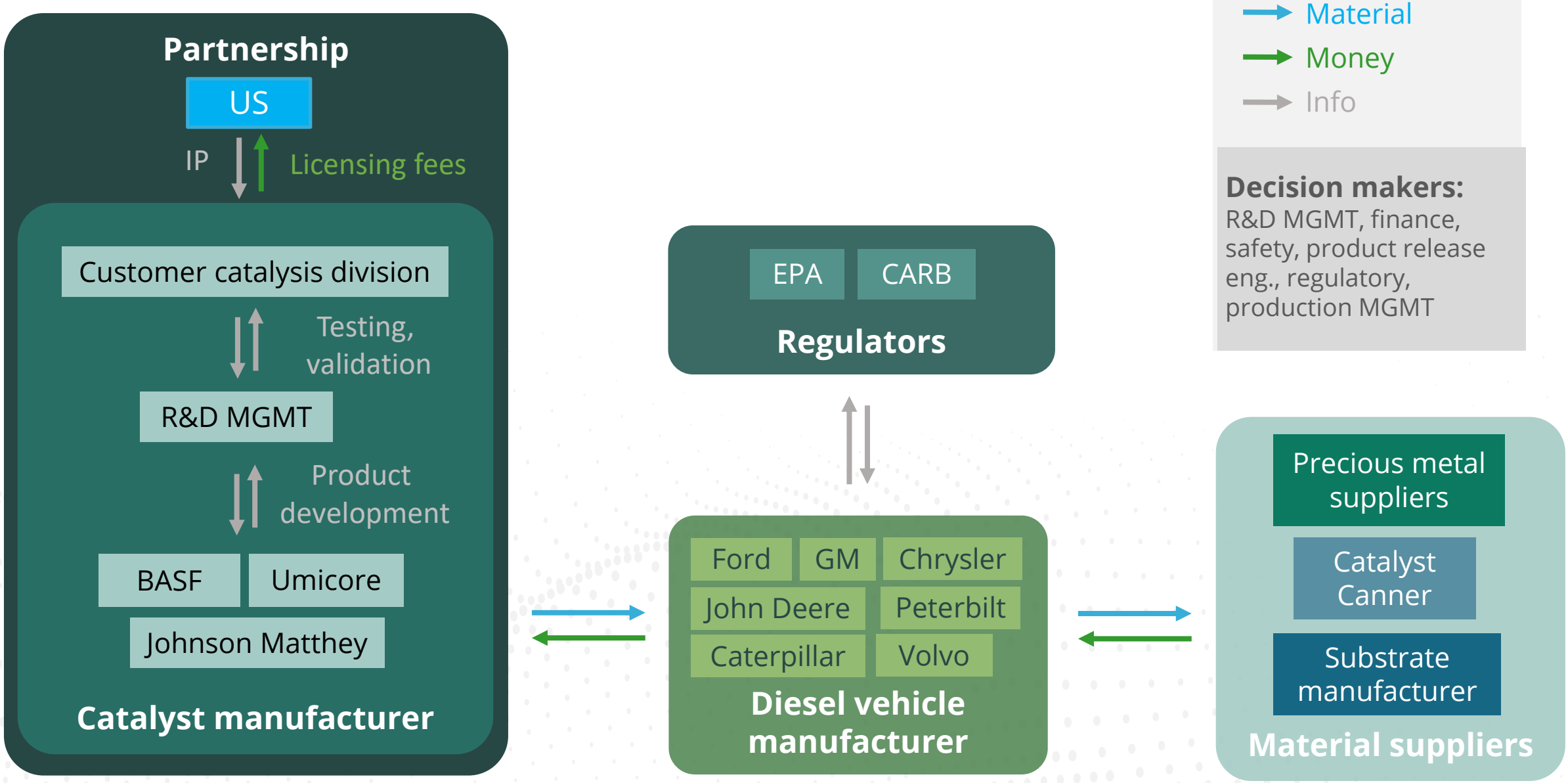
- Initial costs: scale up, validation experiments
- Fixed costs: Salaries, equipment, lab facilities
- Variable costs: Production runs, Raw material (PRM)
- Reduced costs: ~$1100 lower cost for semi truck oxidation catalyst

Revenue Streams

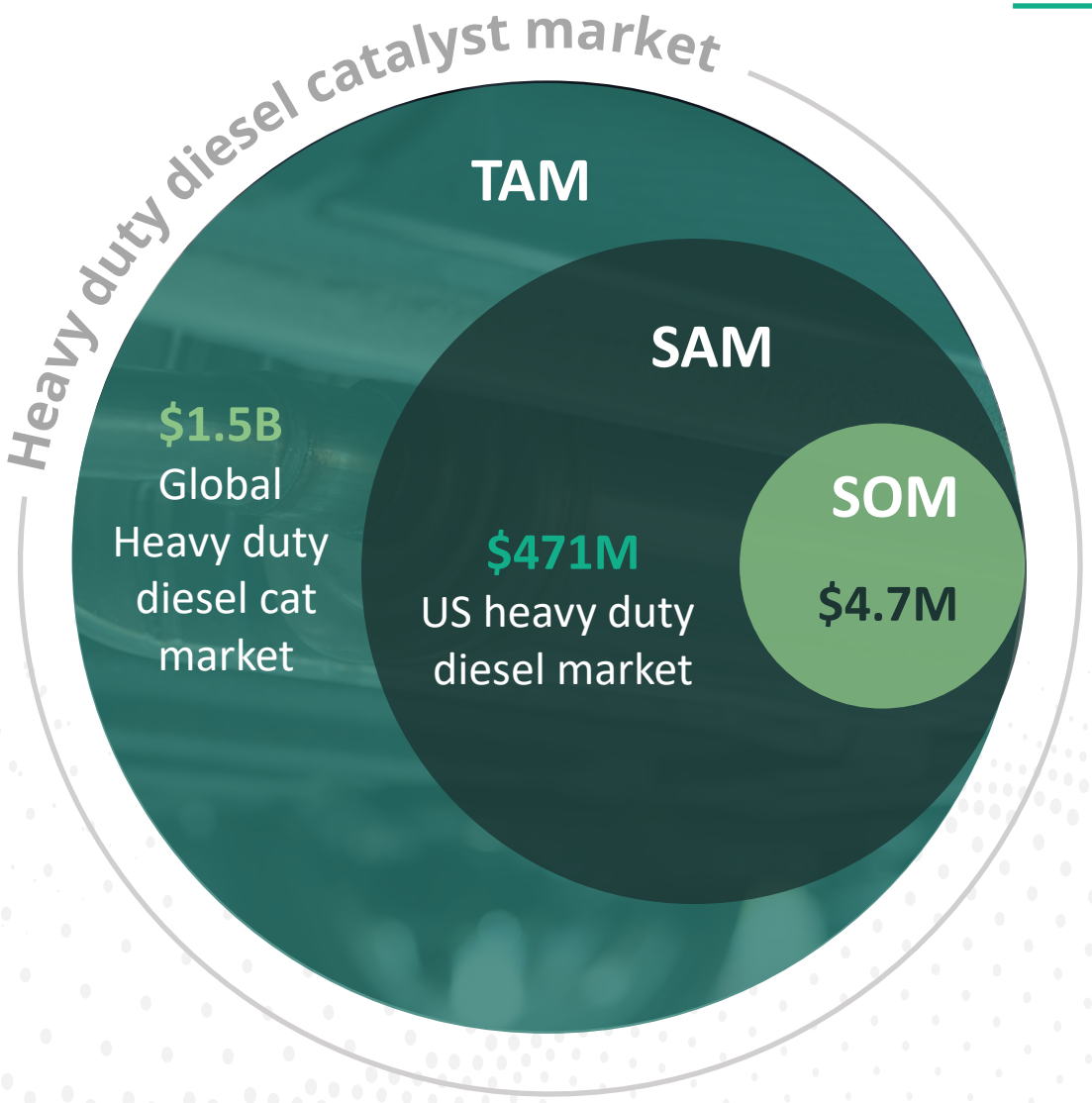
- Catalyst IP licensing Fees
- Royalties

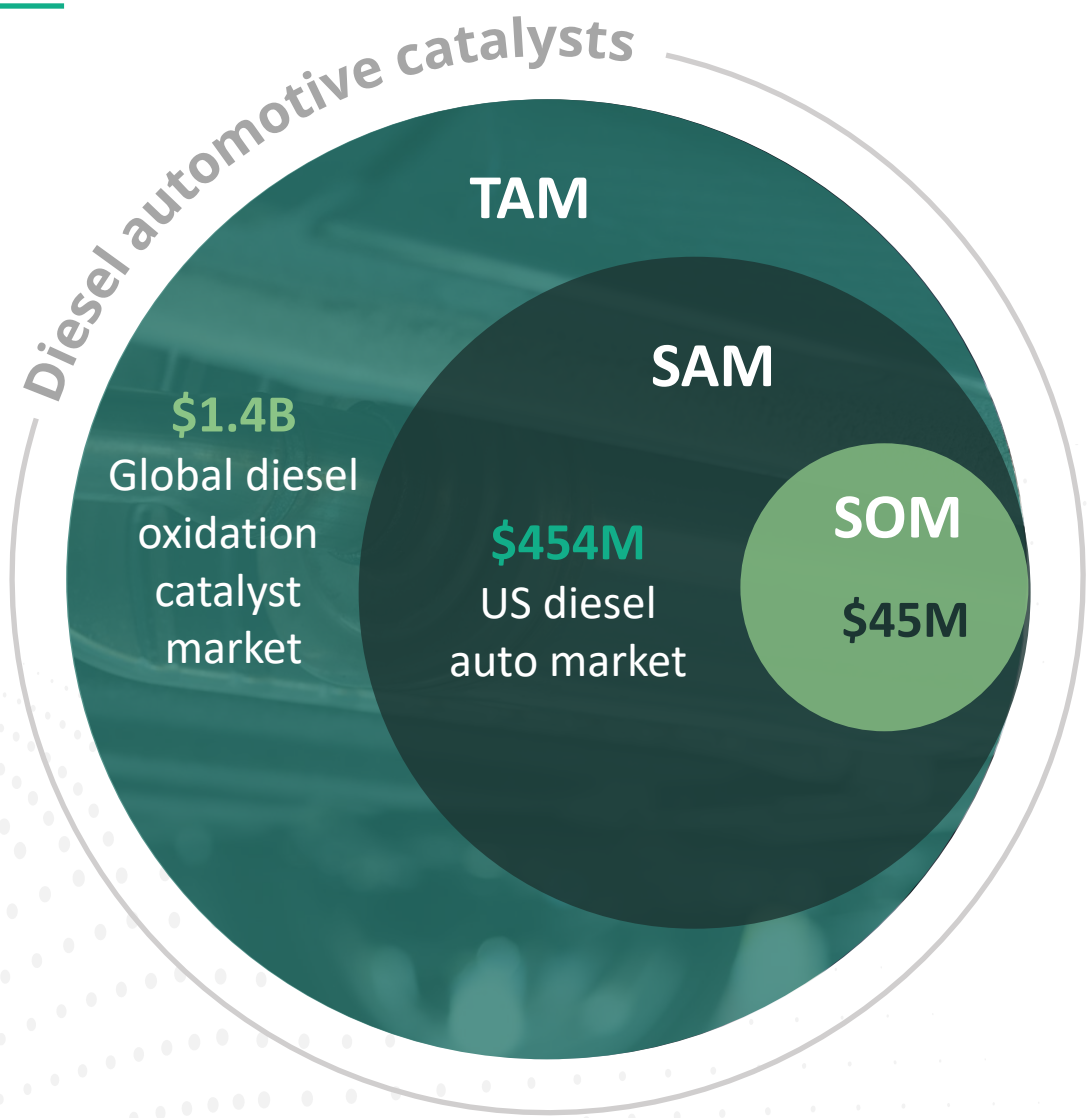
Ecosystem diagram

61 Total interviews



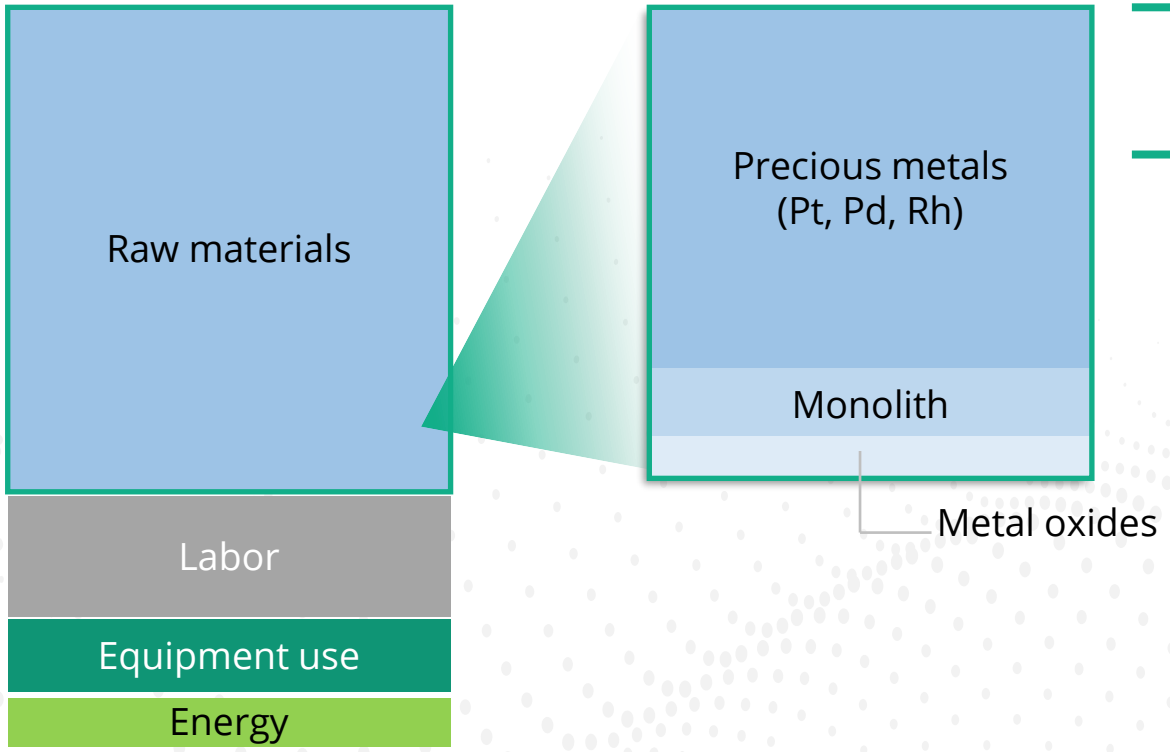
Catalysis market analysis





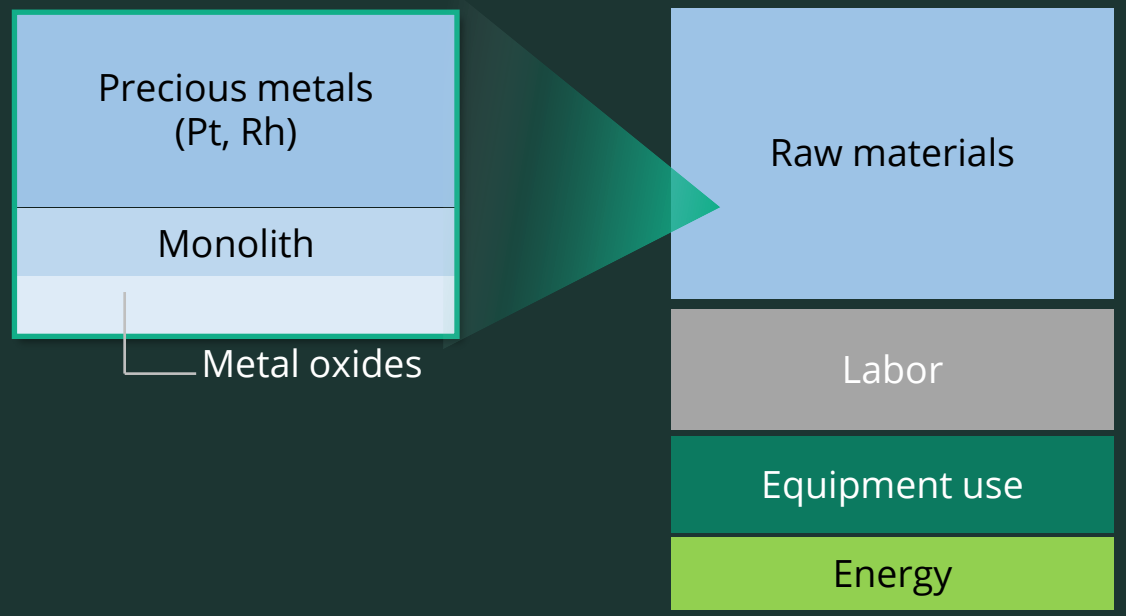
Comparison of conventional and proposed diesel oxidation catalyst cost structure

Estimated conventional DOC cost structure



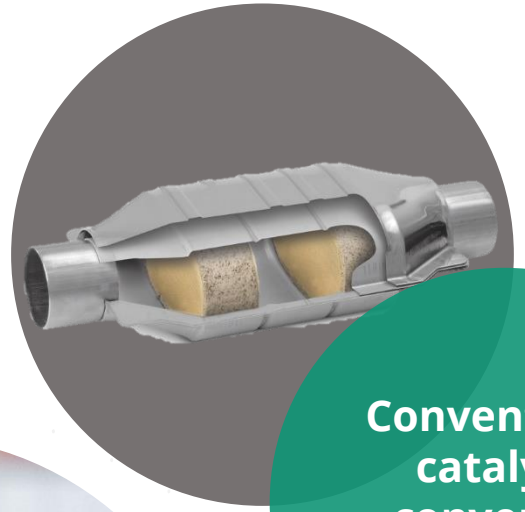
Our estimated cost structure

$1100 savings per Semi-truck DOC



Potential competition and partnerships

Competitors



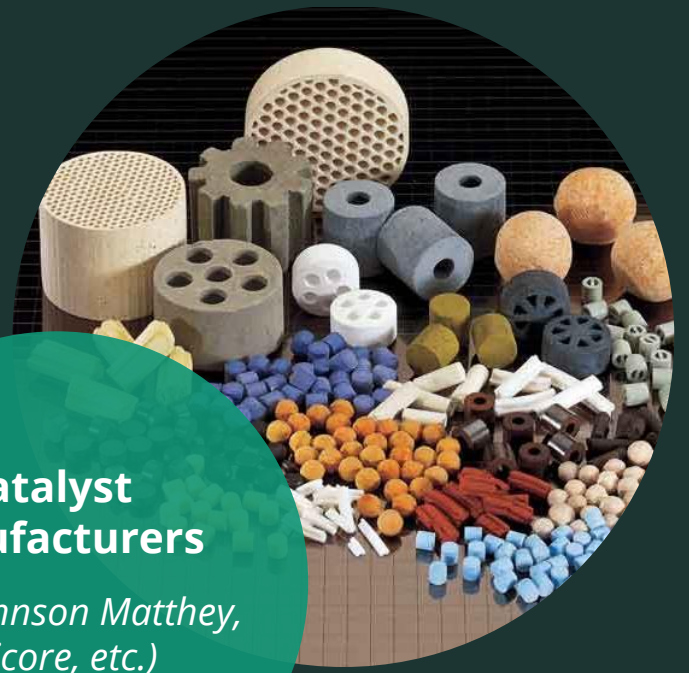
Conventional catalytic converters

(auto manufacturers)

Hydrogen & Electric vehicles

(Tesla, GM, etc.)

Partners



Catalyst manufacturers

(BASF, Johnson Matthey, Umicore, etc.)