PowerCell Sweden AB

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POWERCELL

PowerCell Sweden AB

- **Ort:** Göteborg
- **Historia:** Bygger på ett 20 årigt arv av teknik, IP/patent utvecklade inom Volvo-koncernen, fristående bolag sedan 2008

- **Team:** Team med mycket hög kompetens bestående av 28 heltidsanställda (varav 7 st Tek. Dr och 13 st Civ.Ing.) kompletterat med 10 konsulter
- **Produkter:** Bränslecellsstackar S1, S2 och S3 (under utv) och tillhörande system
  PowerPac (APU - Bränslecell som drivs av reformerad diesel)
  Systemtekniktjänster inom bränslecells- och reformerteknologi
- **Utveckling**: Bränslecells stack S3 och APU system
- **Anläggning**: Komplett Bolag med största bränslecellslaboratoriet i norra Europa, utveckling, inköp, produktion, marknad & sälj och ledningsfunktioner

PowerCell Fuel Cell stacks

Fuel Cell stack S1 : 1-5 kW (i produktion)

H_2 & Reformat

Fuel Cell stack S2 : 5-25 kW (i produktion)

H_2 & Reformat

Fuel Cell stack S3 : 20-100 kW (under utveckling)

H_2

Portfolio

PEM - Fuel Cell Stack	Hydrogen based systems	Reformate based systems
S1 (1-5kW) Product	FC-UPS (1kW) Production	FCM-module (1kW) Prototype
S2 (5-25kW) Pre-production	H_2-REX (20-25kW) Technology development	PowerPac stationary (3kW) Prototypes
S3 (20-100kW) Technology development		

Market for larger PEM fuel cell stacks

1m W | 1 W | 1 kW | 10 kW | 100 kW | 1 MW

Mobila enheter

Datorer

Mikrokraftverk

Telekom

Materialhantering

Personbilar

Kraftverk

Kraft containrar

Fordons-APU

Kyl/Värmetransporter

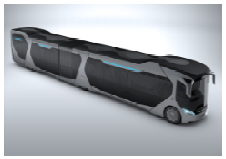
Lastbilar

Industriellt

Militärfordon

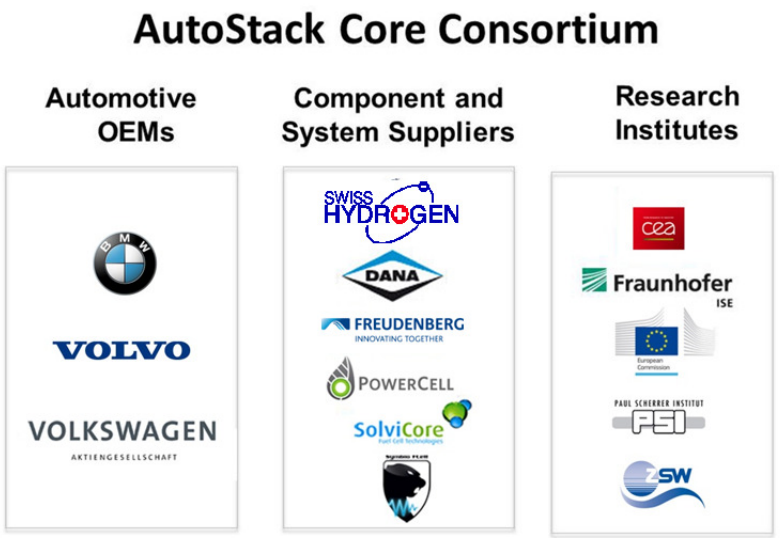
Marint

Räckvidds förlängare


Bussar

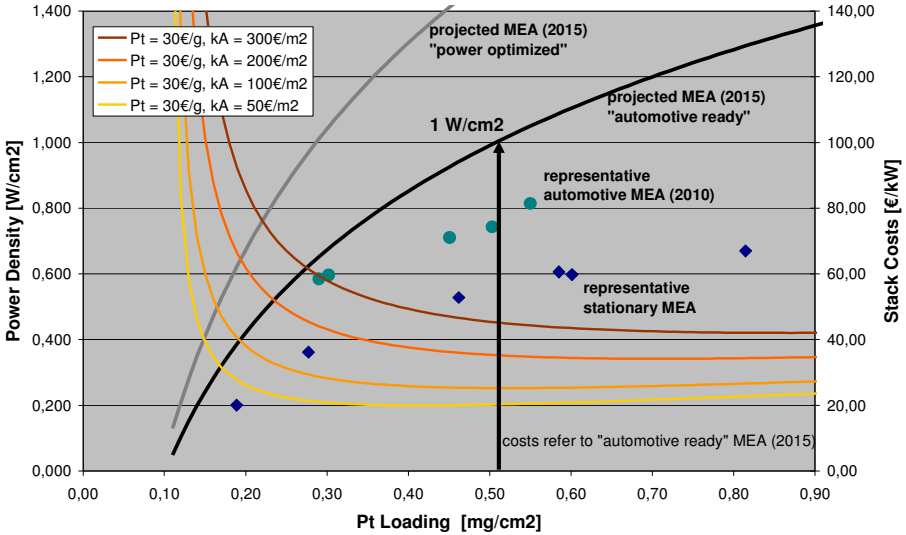
Industrial and research partners have joined forces

- The project addresses a critical gap in the European value chain.
- The objective is to develop best-of-its-class automotive stack technology. Proven in two generation of hard ware Evo1 & Evo2
- The stack platform concept enables additional vehicle and stationary applications.
- The design is exclusively based on industrial components and materials.
- The target is automotive stack production in Europe from 2018/19



autostack core

Power density, Pt-reduction and durability need proper balance



- Loadings of <0.3mg/cm^2 seem achievable in the context of optimized operating conditions.
- Lower Pt-loadings establish conflicts of objective with regard to performance, durability and stack power density.
- Increase of area specific power density delivers an equally effective tool for cost reduction.
- Further optimization potential is tied with OEM system requirements.

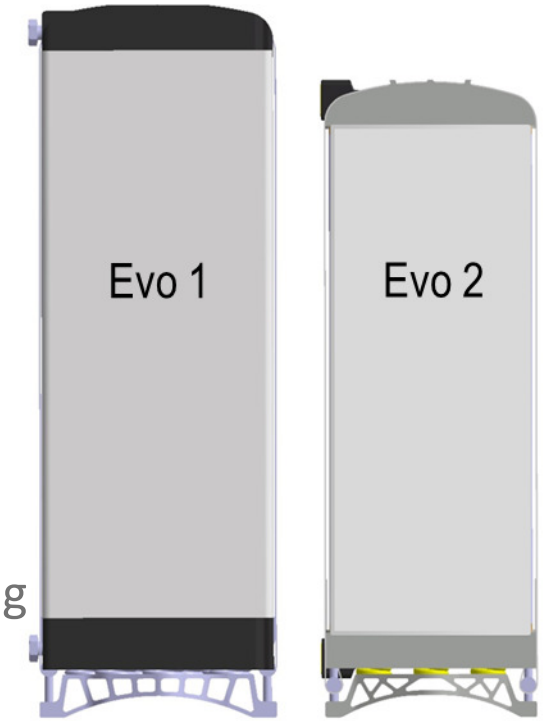
Achievements prove design approach

AutoStack-Core	Specification	Evolution 1	Evolution 2
Calculated power	95kW max cont. 118kW peak 30 sec	94kW max cont. 99kW peak 30 sec	101kW max cont. 110kW max peak
Stack power density	2.8kW/l max cont. 3.4kW/l peak	2.7kW/l max cont. 2.9kW/l peak 30	> 3.6kW/l * > 3.8kW/l
Operating point	1W·cm^{-2} @ 1.5A/cm^2	0.947W·cm^{-2} @ 1.5A/cm^2	t.b.d.
Max operating temperature	95°C	95°C	t.b.d.
Humidification	< 50% RH	50% RH	t.b.d.
Operating pressure	2.2...2.4 max cont. 2.7 max peak	2.2 max cont. 3.0 max peak	t.b.d.
Lifetime	< 12 µV·h^{-1}	49.6 µV·h^{-1}	t.b.d.
Stack target cost @ 120 000/y	< € 40.00/kW	€ 47.83 /kW @ /30 000/y	t.b.d.

* Performance data: Evo 1 – test results, Evo2 calculated based on modelling results.

Outstanding power density addresses packaging and cost

- Improved active to passive ratio
- Lower cell pitch
- Improved material usage
- Lower cost materials
- More rugged design
- CVM integrated in stack housing
- Prototype tooling for housing components
- Stack roll-out starting Q1 2016



Change Evo 1 vs. Evo 2

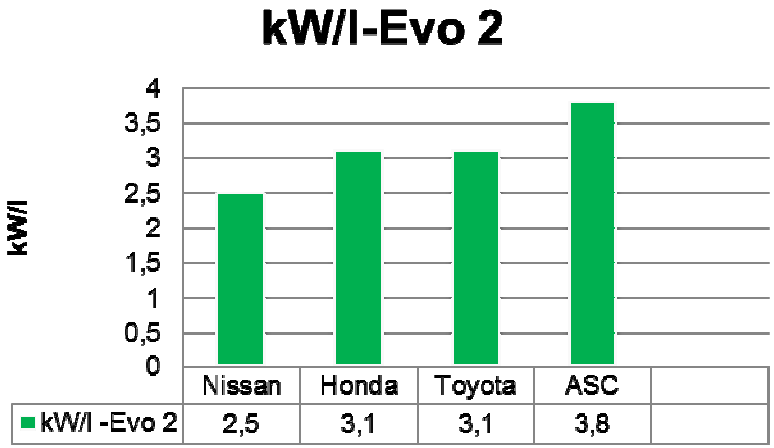
Active/passive ratio	+13%
Cell pitch mm	-17%

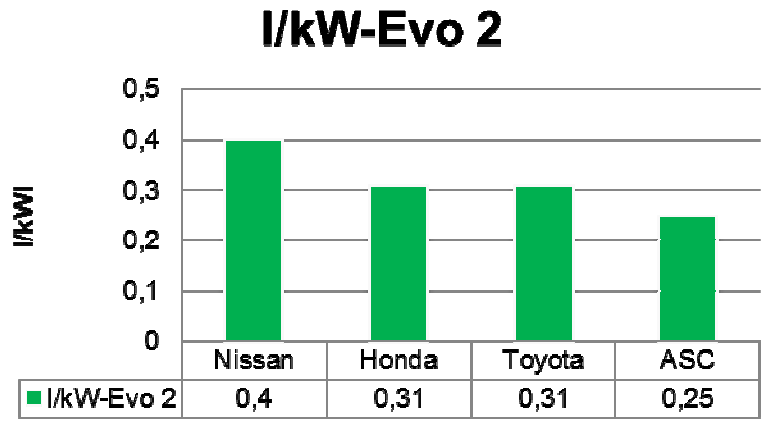
Specifications	Unit	EVO3 Target	EVO1 Outcome	EVO2 Outlook
Outer dimensions (lenght x width x height)	dm	6.5 x 4.3 x 1.55	5 x 4.14 x 1.656	4.9 x 4.15 x 1.49
Volume of the stack exterior	dm3	< 41	34.3	~ 27,7
Weight without fluids and fully humidified membranes (net weight)	kg	< 44	46,3	~ 33,1

Evo 2 establishes best-in-class power density

- State-of-the-art benchmark is 3,1kW/l (Toyota).
- In absence of reference conditions, comparison is difficult.
- System requirements need to be considered.
- ASC Evolution 2 seems most advanced in industry.

Reference condition – ASC stack peak power: 0,6V@1,9A/cm^2
Stack volume Evolution 2 – 27,7l



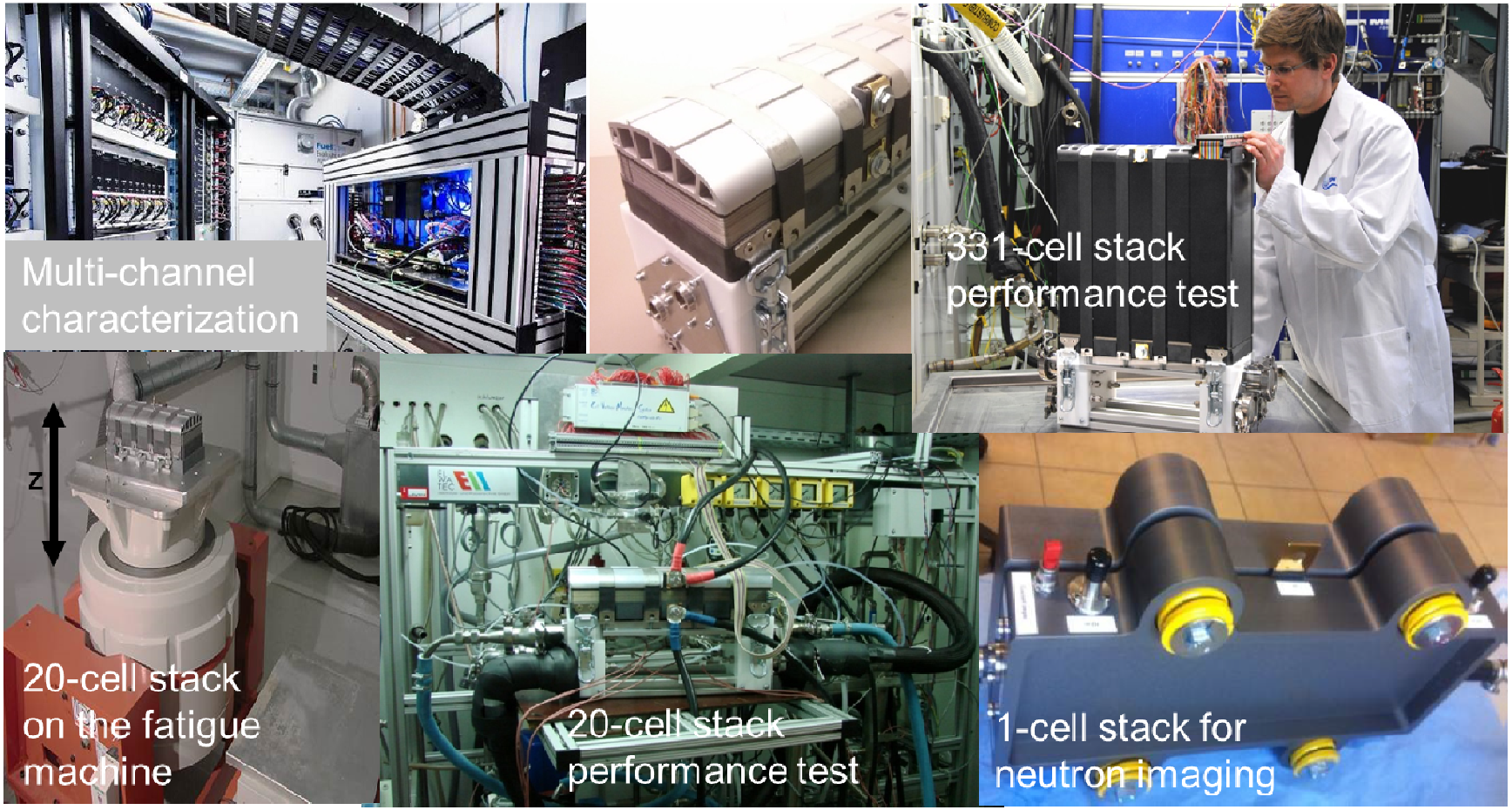


Extensive stack test program provides design validation

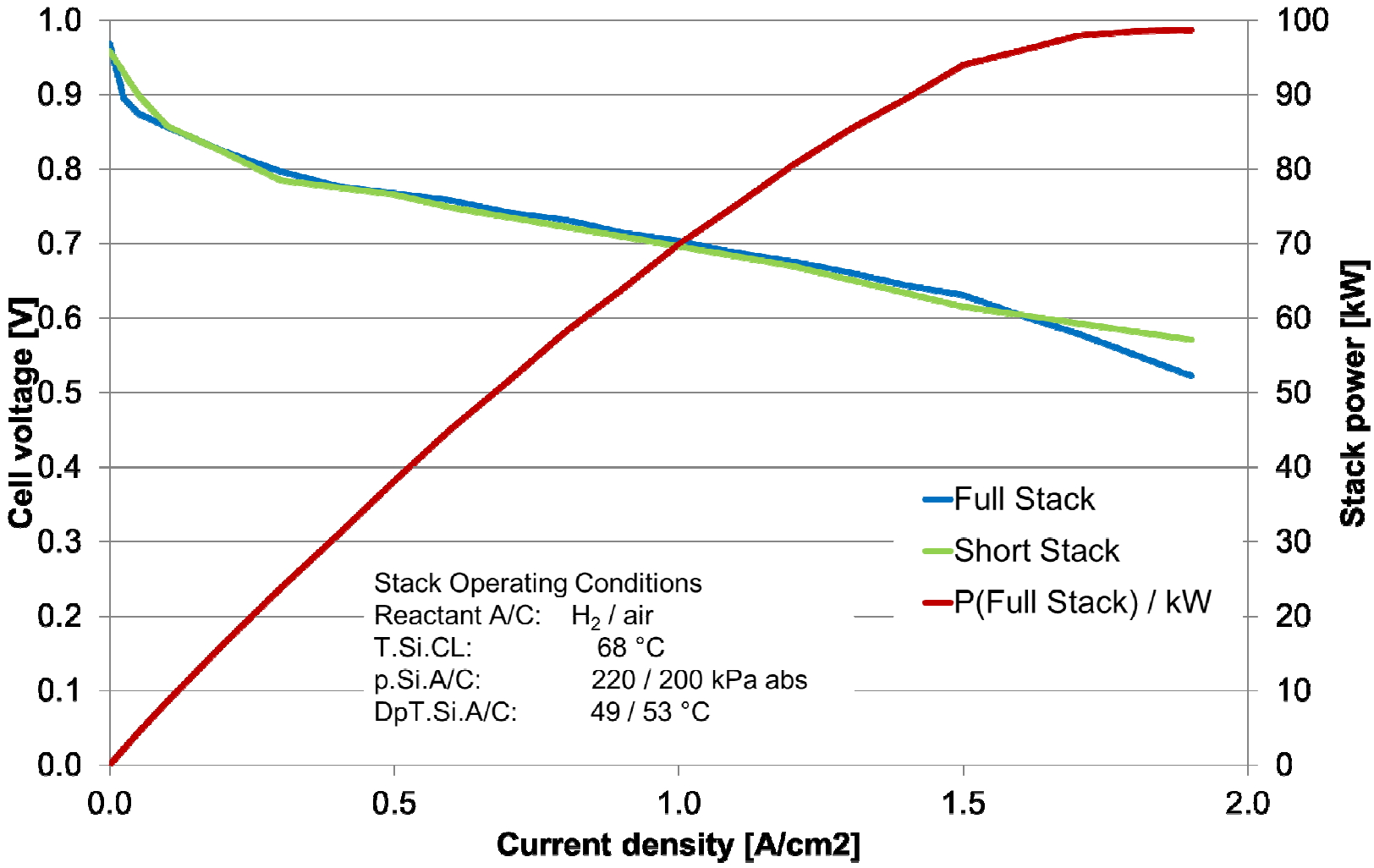
	Performance Testing (Sensitivity)
ASC01	Current-Voltage Curve
ASC02	Sensitivity to operating temperature
ASC03	Sensitivity to anode humidification
ASC04	Sensitivity to cathode humidification
ASC05	Sensitivity to anode stoichiometry
ASC06	Sensitivity to cathode stoichiometry
ASC07	Sensitivity to outlet pressure
ASC08	Sensitivity to N2-content in the fuel
	Performance Testing (Check of Specification)
ASC09	Proof of full load capability
ASC10	Proof of low load stability (200 mA/cm2)
ASC11	Proof of overload capability (1.9+ A/cm2)
ASC12	Determination of warm start behavior
ASC13	Determination of cold start behavior
ASC14	Determination of freeze start behavior
ASC15	Determination of minimum start-up-temperature
ASC16	Determination of stability under anode recirculation
	Endurance testing
ASC17	Performance stability under dynamic load
ASC18	Performance stability unter repeated warm start/stop
ASC19	Performance stability under repeated cold start/stop
ASC20	Performance stability under repeated air start/stop
ASC21	Performance stability under idling conditions
	Special Tests (Safety)
ASC22	Leak testing (general)
ASC23	Leakage after shock and vibration
ASC24	H2-crossover leakage
ASC25	H2 external leakage
ASC26	Performance after shock and vibration
ASC27	H2-emission as a function of operating conditions
ASC28	Segmented cell tests
ASC29	Neutron imaging tests

A total of 24 short and full size stacks were tested at 6 partners for a total period of 9 months and up to 1000h of operation.

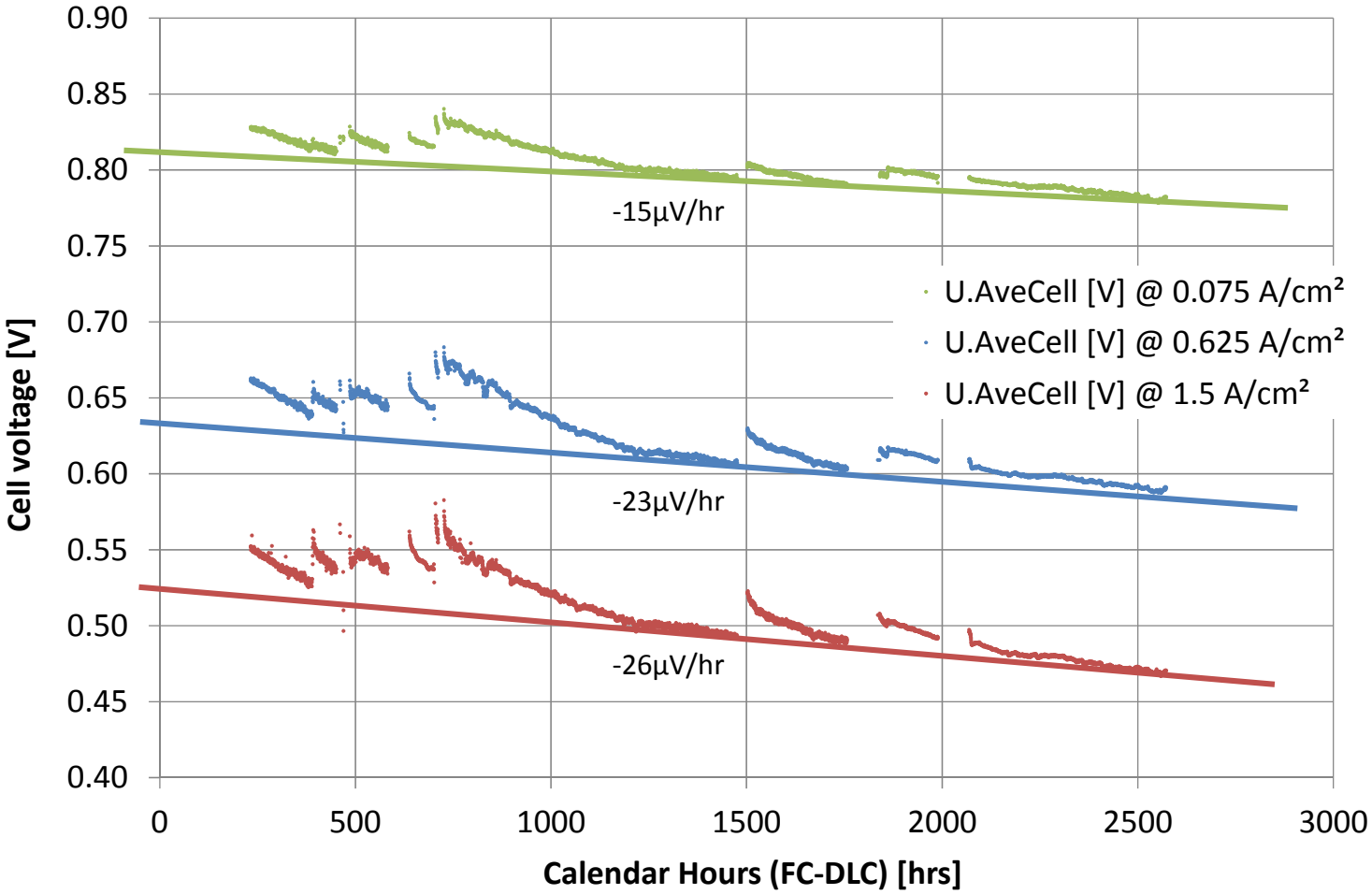
Various methods to assess specific design properties…



Short and full size stacks test results

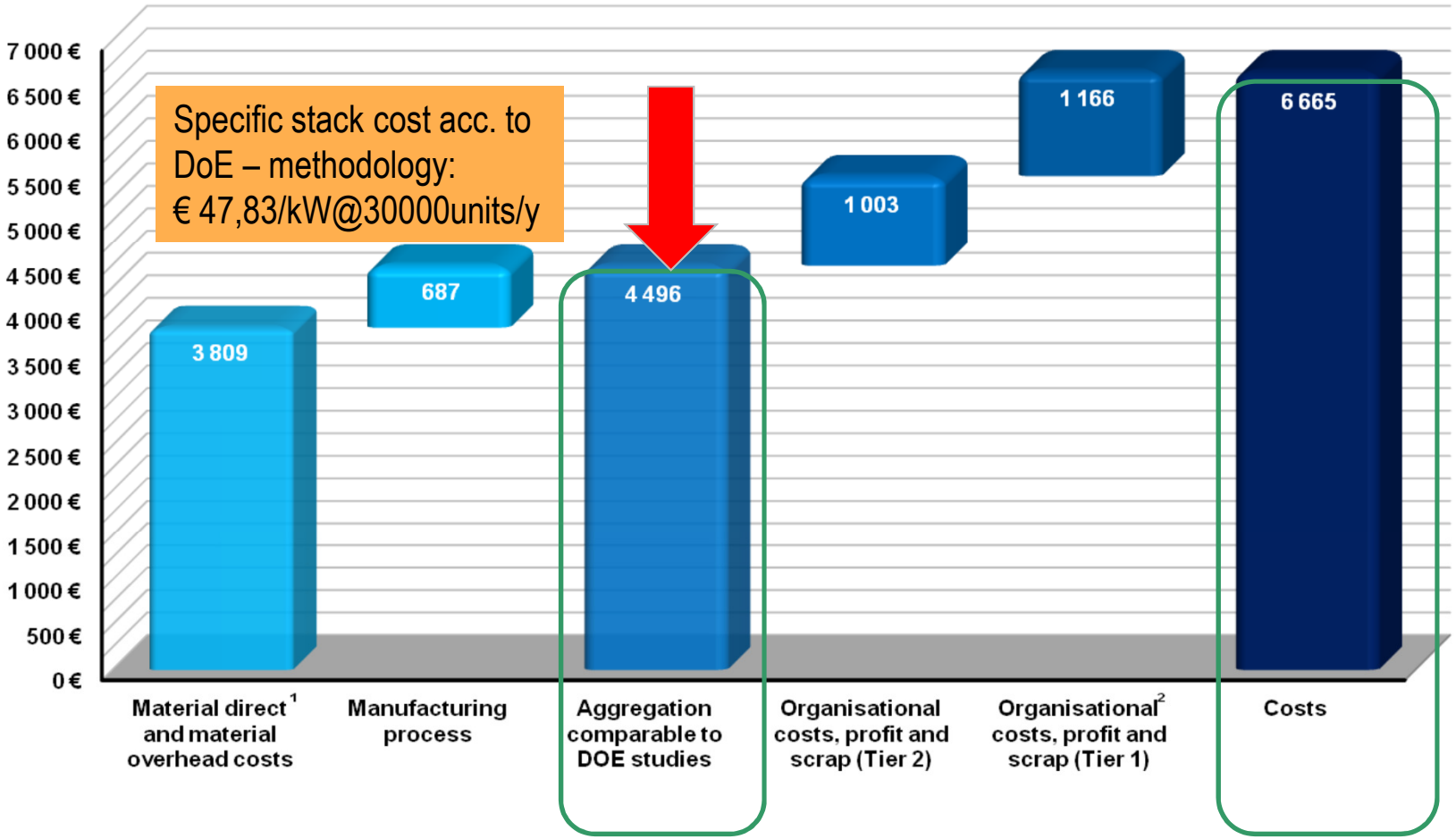


Initial durability results from EVO1



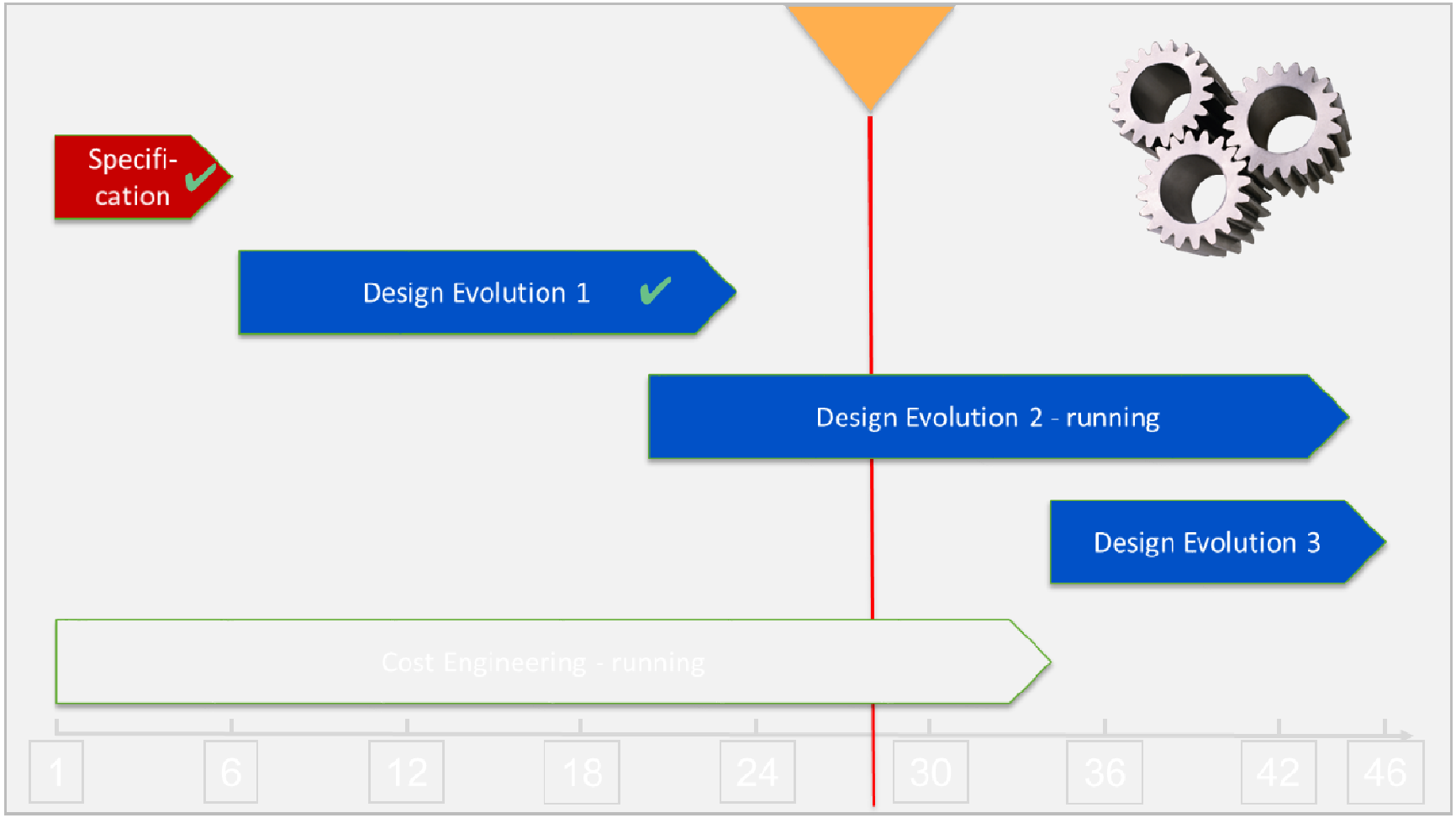
Dynamic durability testing results are in line with expected range for the design status

Cost



Evolution 1 stack manufacturing cost is near DoE target for automotive application

Project on track to deliver against targets



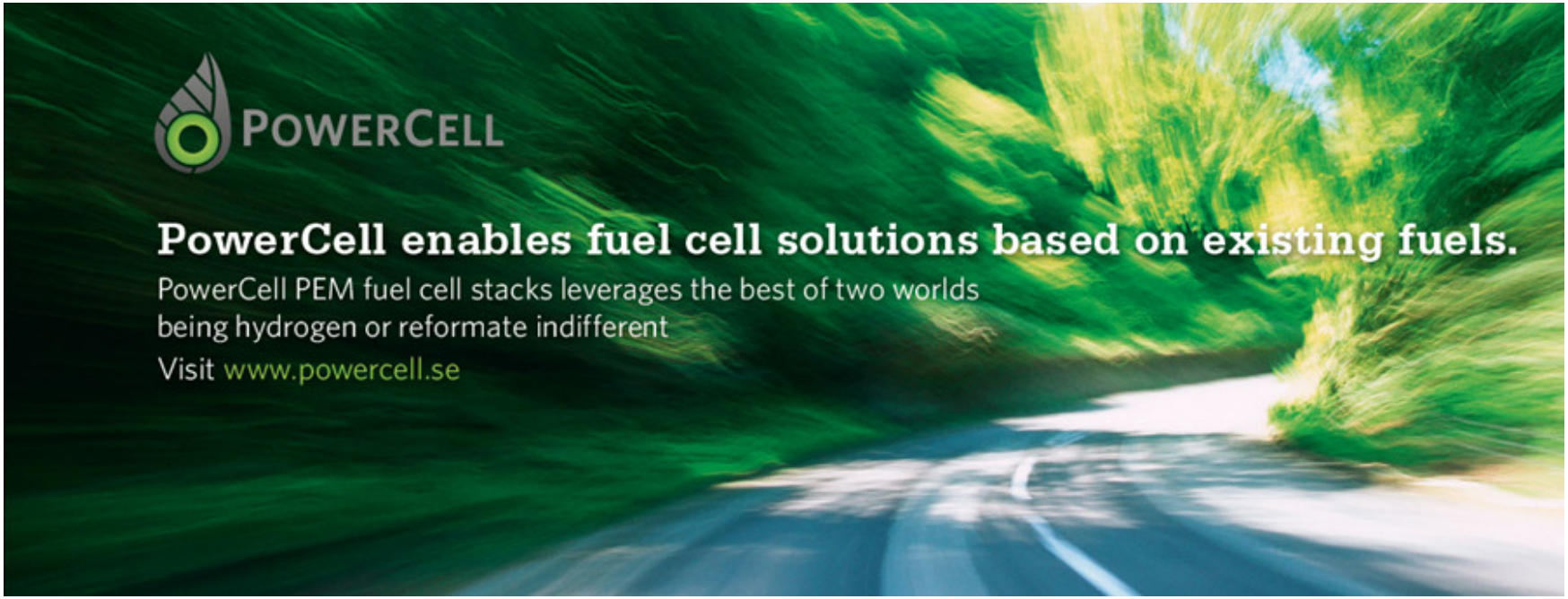
Project status

After 18 months only, the consortium has delivered a comprehensive stack design with the potential for technology leadership:

Technical status provides pathway towards best-in-class automotive stack hardware

- Highest stack power density based on proven Evolution 2 external stack design
- Short and full size stacks with almost identical performance
- Stable stack operation at specified anode and cathode stoichiometries
- Low sensitivity versus temperature, cathode/anode humidification, nitrogen content
- Pressure sensitivity up to 3bara as specified and expected
- Freeze start capability demonstrated from -20 ° C without pre-heating
- Successful vibration testing w/o visible performance losses
- Solutions at hand to achieve or exceed final stack specification.

Thank you for listening



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