Stakeholder Inventory and Supply Chain Analysis

Autostack workshop on intermediate results

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Analysis of the Supply Chain

Objectives

1. Generate an inventory of the European stack component supply industry

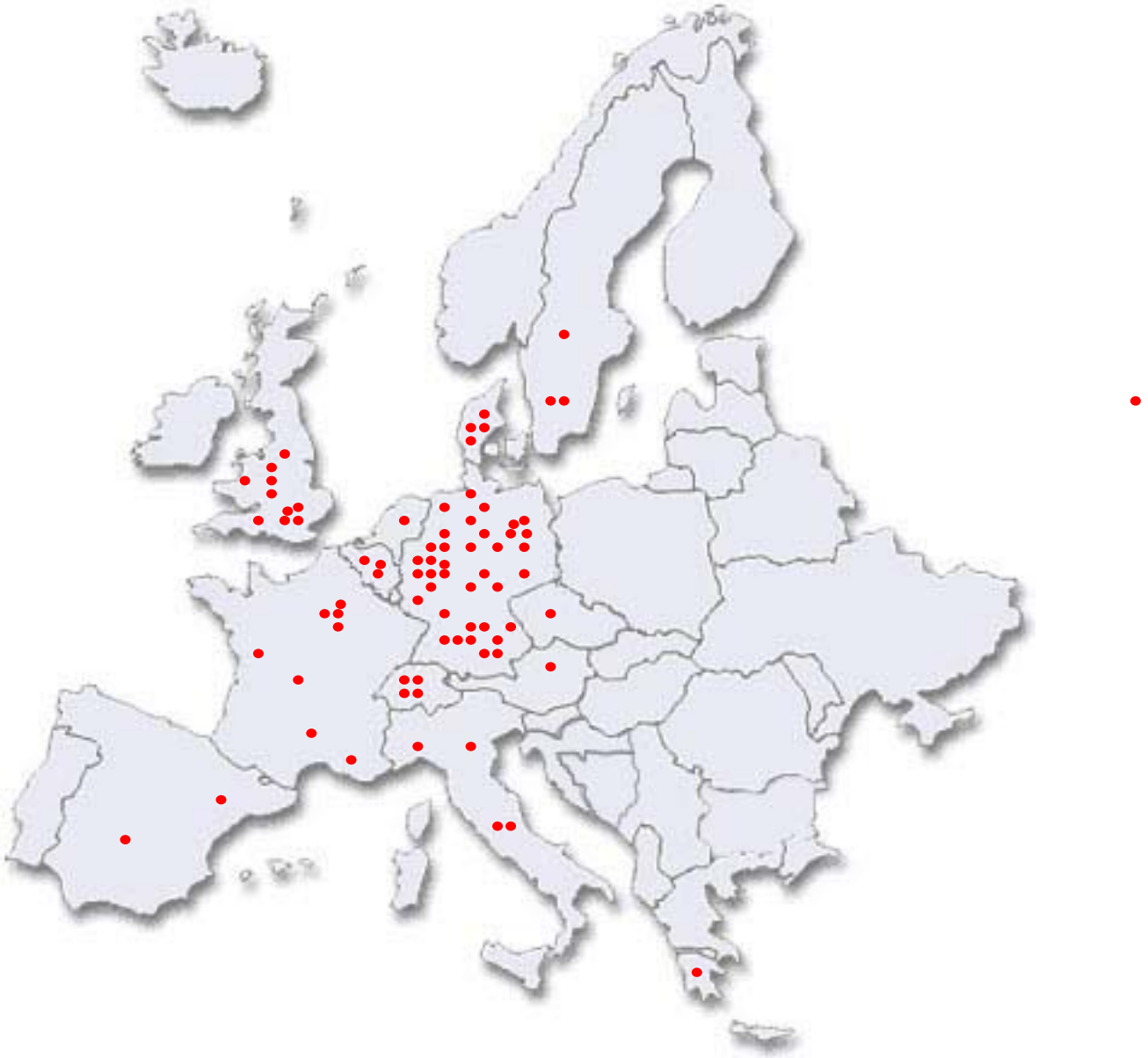
2. Analyze status of present and future products

3. Identify gap between goals and state of the art

Component properties

Component cost

Inventory of the stack component industry



Inventory of the stack component industry

ca. 60 European companies are active in PEFC components and/or advertise „fuel cell“ in their port-folio

	Stakeholder
Catalyst	
	Umicore AG & Co. KG
	Johnson Matthey Fuel Cells
	W.C Heraeus GmbH
	DKL Metals Ltd.
	MMC Norilsk Nickel
	Evonik
	Future Carbon GmbH
	Catal
	Tanaka
	Acta spa
	Cabot Superior Micropowders
	Engelhard Corporation
Membrane	
	SOLVAY
	Solvay SOLEXIS S.p.A.
	FuMaTech
	Bayer Technology Services
	Arkema
	Evonik
	ITM Power
	Mega AS
	BASF Fuel Cell
	Danish Power Systems
	Advent Technologies
	DuPont
	3M
	W.L. Gore & Associates GmbH

	Stakeholder
Bipolar Plate	
	Reinz Dichtungs GmbH
	Schunk Kohlenstofftechnik
	Wilhelm Eisenhuth
	Bayer Technology Services GmbH
	Bac2 Conductive Composites
	Borit NV
	Cellimpact Morphic Group
	Weidmann Plastics Technology
	Hüttenberger Produktionstechnik GmbH
	Tribecraft AG
	Precision Micro
	FIX Maschinenbau GmbH
	Gräbener Maschinentechnik GmbH & Co. KG
	GrafTech International Ltd.
	Cabot Corporation
	Metro Mold & Design Corporation
	SGL Carbon Group
	ElringKlinger AG
GDL	
	Freudenberg FFCCT
	SGL Carbon Group
	MAST Carbon Technology
	Technical Fibre Products Ltd.
	Toray International Europe GmbH
	Ballard Materials Products Inc.
	CeTech Co. Ltd.

	Stakeholder
GDE	
	Johnson Matthey
	Solvicore GmbH
	PaxiTech SAS
	baltic FuelCells GmbH
MEA	
	Solvicore GmbH
	Johnson Matthey Fuel Cells
	FuMA-Tech GmbH
	IRD Fuel Cell Technology
	PaxiTech SAS
	Evonik
	baltic FuelCells GmbH
	BASF Fuel Cell
	Danish Power Systems
	Advent Technologies
	DuPont
	W.L. Gore & Associates GmbH
	3M
	ITM Power
Sealing	
	Reinz Dichtungs GmbH
	FFCCT
	Tribecraft AG
	AcTech GmbH

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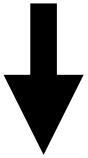
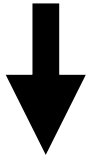


Component properties



Component cost

Data analysis

Study for the purpose of Autostack project

- limited to European suppliers
- includes data collection of product properties and cost
- for preliminary mass production (250-25.000 stacks/year)
- Timeframe 2010-2020
- for stack specification requested by the consortium

→ Not all data statistically evaluable

→
- 350 cm^2 active area
- 1 W/cm^2 power density
- 0% rH at anode,
  < 50% rH at cathode
- …

Methodology

Two step approach

Step 1: Short questionnaire (Sept. 2010) to all European PEFC component supplier

Methodology

Example: **Cost range**

(□< 1 <□< 2 <□< 5 <□< 10 <□€/unit for…)
reply rate: 34% (n=24)

Business	Company
MEA	IRD Fuel Cells Ltd. ITM Power Plc PaxiTech SAS Danish Power Systems BASF Fuel Cell Inc. SolviCore GmbH & Co. KG Johnson Matthey Fuel Cells Ltd.
Membrane	Danish Power Systems ITM Power Plc Solvay S.A. BASF Fuel Cell Inc.
Catalyst	Umicore AG & Co KG Johnson Matthey Fuel Cells Ltd.
GDL	Freudenberg FCCT KG Toray International Europe GmbH SGL Technologies GmbH
Sealing	Freudenberg FCCT KG
Bpp	Bac2 Limited ElringKlinger AG Borit NV Dana Morphic Cellimpact Eisenhuth GmbH & Co. KH Gräbener Maschinentechnik

Methodology

Two step approach

Step 1: short questionnaire (Sept. 2010) to all European PEFC component supplier

Step 2: NDA; extended questionnaires and interviews (Nov. 2010)

→ Data anonymisation based on averaging (a minimum of 3 replies required)

Methodology - Summary

Short questionnaires sent:	65
Reply rate:	46%
Filled questionnaires:	24 (34%)
Interest in ext. Stakeholder group:	16

Extended questionnaires / interviews:	16
Reply rate:	74%

Analysis of the Supply Chain

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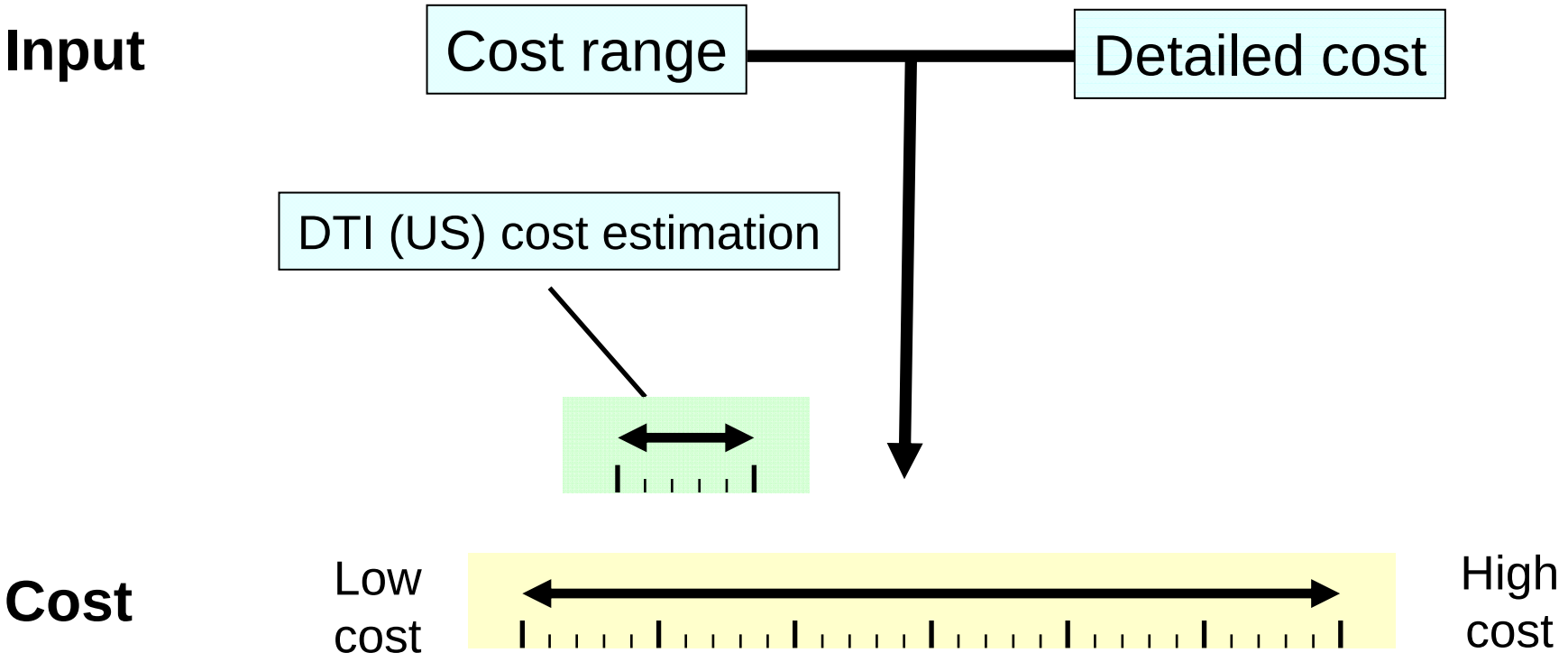
Component properties

Component cost

Cost evaluation



DTI study on cost estimation

Composite BPP

	Annual Production Rate	1,000	30,000	80,000	130,000	500,000
2010	Materials ($/stack)	$78.18	$78.18	$78.18	$78.18	$78.18
	Manufacturing ($/stack)	$288.37	$296.42	$294.44	$294.04	$292.99
	Tooling ($/stack)	$0.58	$0.20	$0.20	$0.20	$0.20
	Total Cost ($/stack)	$367.13	$374.80	$372.82	$372.42	$371.36
	Total Cost ($/$kW_{nrt}$)	$4.59	$4.68	$4.66	$4.66	$4.64

Metallic BPP

	Annual Production Rate	1,000	30,000	80,000	130,000	500,000
2010	Materials ($/stack)	$217.08	$217.08	$217.08	$217.08	$217.08
	Manufacturing ($/stack)	$158.47	$18.89	$16.95	$16.50	$16.10
	Tooling ($/stack)	$99.94	$88.52	$88.69	$89.39	$88.97
	Secondary Operations: Coating ($/stack)	$1,208.80	$109.66	$117.23	$110.05	$106.92
	Total Cost ($/stack)	$1,684.28	$434.15	$439.95	$433.03	$429.07
	Total Cost ($/$kW_{net}$)	$21.05	$5.43	$5.50	$5.41	$5.36

B. D. James, J. A. Kalinoski, K. N. Baum, DTI,
Contract Nr. DE-AC36-08GO28308, Virginia, USA, 2010.

Stack components

- Membrane
- Catalyst
- GDL

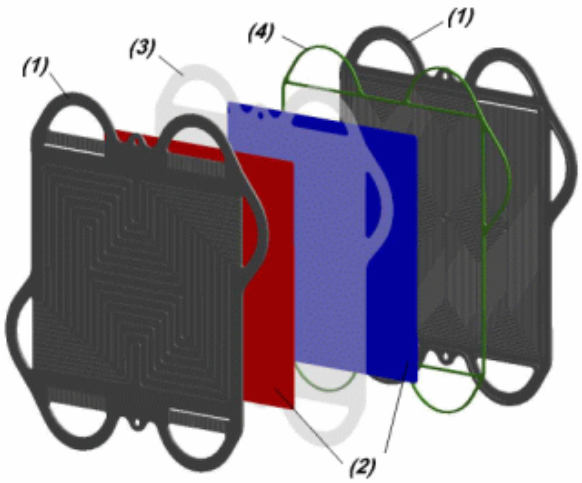
→ MEA

- Material
- Process

→ BPP → Metallic / Composite

- Material
- Process

→ Sealing



State of the Art - MEA

- Required power density is only achievable with a higher PGM loading
- Low PGM loading is in principle not an issue
- If roll good is desirable, development is necessary

State of the Art - Membrane

- Durability is still critical and may not be sufficiently analyzed
- Membrane swelling needs further improvement
- Proton conductivity at required rH is still critical

State of the Art - metal BPP

- The desired cell pitch is with an average sheet thickness of 0.065 mm feasible
- Additional coating and integrated sealing can mostly be provided (->properties of coating?)
- Durability may not be sufficiently analyzed

State of the Art - carbon BPP

- The thickness of carbon BPP is highly critical
- Additional treatment and sealing are partly provided
- The cost are critical

Thank you very much for your kind attention