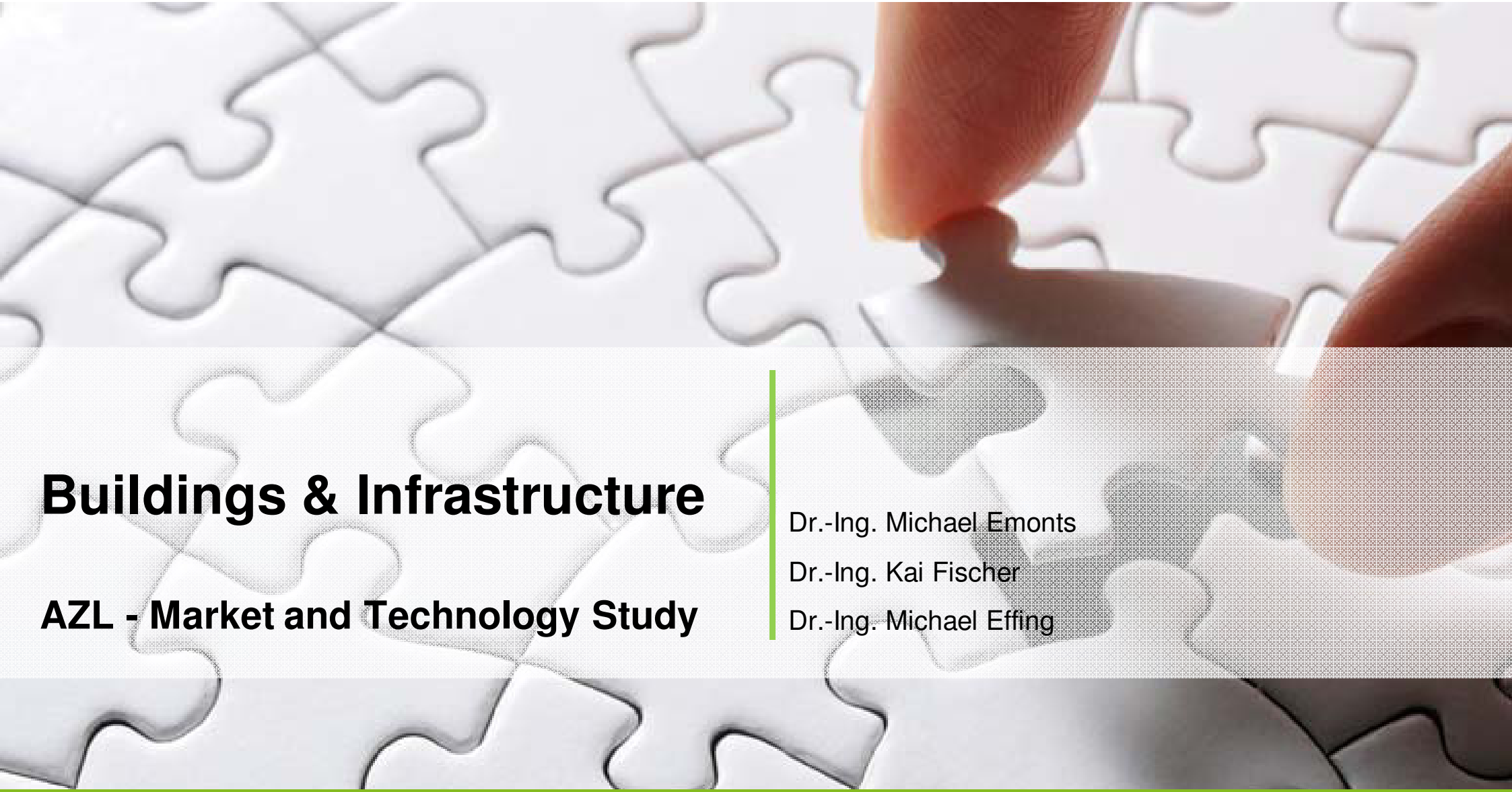
in cooperation with:

AZL Aachen GmbH

AZL Aachener Zentrum für integrativen Leichtbau

RWTH AACHEN UNIVERSITY



Buildings & Infrastructure

AZL - Market and Technology Study

Dr.-Ing. Michael Emonts

Dr.-Ing. Kai Fischer

Dr.-Ing. Michael Effing

AZL – Market and Technology Study

„Lightweight Composite Structures for Buildings & Infrastructure“: Market

in cooperation with:






Buildings & Infrastructure (B&I) Market*:

- **34%** of Glass Fiber Market is B&I
- **23%** of Carbon Fiber Market is B&I
- B&I Market in Europe: **8 – 10 Bill. EURO**
- Overall Market in Europe: approx. 30 Bill. EURO

Approx. 30% of overall Market in Europe is B&I

Reasons for Composite Applications:

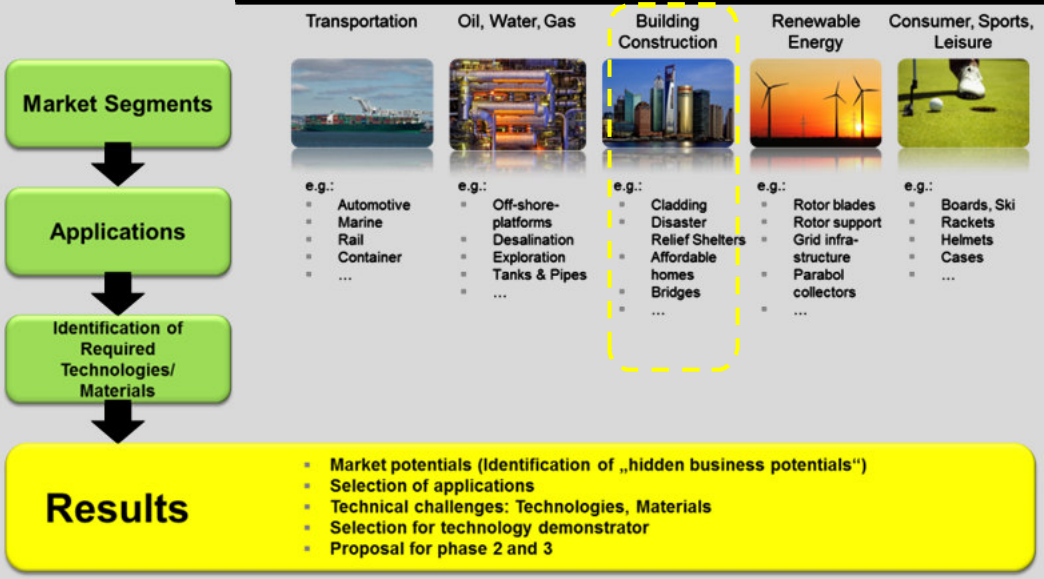
- Lightweight Design
- Corrosion Resistance
- Thermal/ Electr. Insulation
- Freedom of Design (especially for Large structures)
- Low Invest Cost

Buildings & Infrastructure will be one of the most attractive Growth Markets for Composite Applications

*Market Report AVK 2015

Background and Motivation

Background: AZL Market and Technology Study (2013 - 2014)



Final Study Results (2014)

- Start of project: March 2013, duration: 12 months
- International industrial consortium with 33 companies
  - 14 Material Suppliers, 6 OEM, 7 Tier 1/2, 6 Equipment Provider

- ➔ Identified **450 attractive components**/ applications within the 5 key segments
- ➔ **Technology analyses** of **50 highlight components** incl. market size and development, technological maturity, competitors etc.
- ➔ **12 detailed business cases** including comprehensive profitability, technology analyses and concept development for new profitable production chains

New Study (2016)

New Request from our industrial AZL-Partner-Network:

- ➔ New Market and Technology Study with Focus on **„Buildings & Infrastructure":**
  - Update/ enlargement of component identification and analysis in this segment
  - Detailed technology and supplier analyses
  - Concept development for efficient profitable production technologies (process chains) incl. cost engineering analysis

AZL – Market and Technology Study

„Lightweight Composite Structures for Buildings & Infrastructure“: Application Examples

in cooperation with:

AZL Aachen GmbH

AZL Aachener Zentrum für integrativen Leichtbau

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Markets

Market Segments (Examples)

Applications/ Components (Examples)

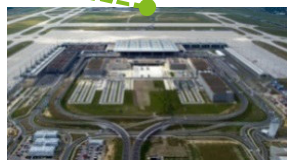
&

Buildings

Infrastructure

Residential

Non-residential



Energy supply

Water constr.

Special constr.

Ultraslim window frames

Sun Protection

Room units

Expandable shelters

High voltage pylons

Flexible pipelines

Non-corrosive pipeline joints

Underwater construction components

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Systematic Approach

in cooperation with:

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Systematic structuring approach:* ***Example:***

Pilot Study

»Level 0« - Markets

- Buildings
- Infrastructure

»Level 1« - Market Segments

- Structure for example based on value-added steps, final products or technologies

➔ Result: »segments«

e.g. Residental, Water Supply, Energy Supply

»Level 2« - Applications

- Key applications and services within the identified market segments

➔ Result: »applications« and »services« probably offering hidden business potentials**

Electrical Transmission, Water Transmission, Building Components

»Level 3« - Components

- Breakdown on system and component level

➔ Result: required »components« in order to address above mentioned business opportunities

Pipes, Ducts etc.

* *This diagram only represents the schematic conceptual approach of the market study. The final structure might deviate due to the characteristics of the technology fields at hand.*

** *business potentials are to be found either in the form of lightweigt components, technological capabilities, new materials or new services*

Systematic Selection Process

Detailed Analysis

Required technologies, materials and services

- Identification of key enabling technologies, materials or services based on application/ component requirements

Detailed business cases and technolgy evaluation

- Detailed assessment of selected business opportunities

➔ **Overall target:** Uncovering/ Evaluating economically attractive and technologically feasible hidden business potentials

AZL – Market and Technology Study

„Lightweight Composite Structures for Buildings & Infrastructure“: Project Frame

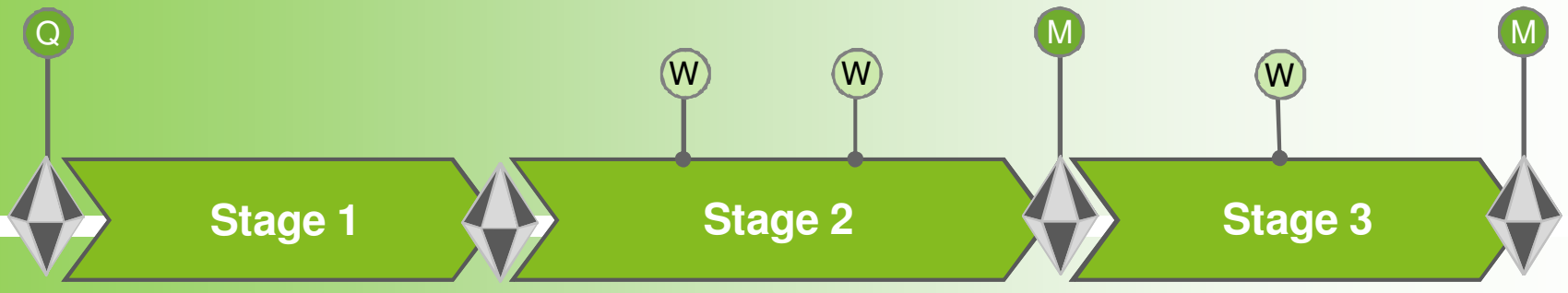
in cooperation with:

AZL Aachen GmbH | AZL Aachener Zentrum für integrativen Leichtbau | RWTH AACHEN UNIVERSITY

external

2 months Pilot Study | 2 months Technology/ Market Analyses | 2 months Business Cases

∑ 6 months



Kick-off October, 2016 | **Workshop 1** Dec., 2017 | **Workshop 2** March, 2017 | **Final Meeting** May, 2017

internal

Stage 1 Content:

- Kick-Off **Questionnaire**
- **Segmentation** and **pilot analyses** of segment „Buildings & Infrastructure“
- Workshop-based pre-evaluation and **selection of applications** where hidden potentials are expected
- **Breakdown** to application and/or component level

➔ *Information basis for systematic application/ component selection*

Stage 2 Content:

- Systematic **selection** of attractive **applications and components**
- Detailed **market and technology studies** for selected applications and components
- Derivation of **required technologies, materials or services** to tap hidden potential markets

➔ *Information basis for identification of highlight market opportunities*

Stage 3 Content:

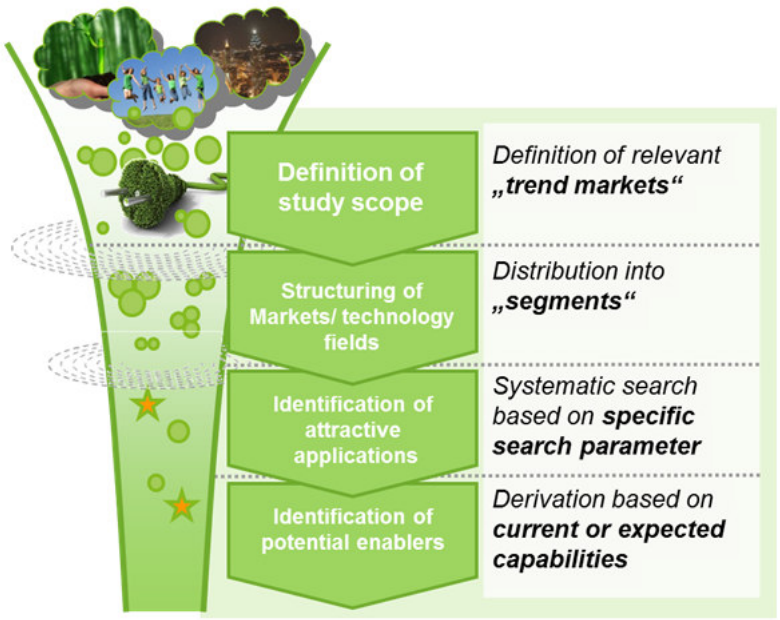
- Identification of highly attractive **market opportunities**
- Derivation of detailed **business cases** and **technological feasibility studies** for selected applications/ components (deepdive market and technology analyses for full technologic and economic evaluation, incl. analyses of production cost structures)

➔ *Basis for subsequent **prioritization of technology demonstrators***

Exemplary Proceeding
From 100 Technologies to 10 Highlights

in cooperation with:

Systematic approach:



Exemplary results:

»Level 0« - Markets

- Buildings
- Infrastructure

»Level 1« - Market Segments

- Derivation of **12 market segments**
- Selection of **6 attractive key market segments** based on pilot segment studies

»Level 2« - Applications

- Derivation of **~100 attractive technologies/ applications** within the key market segments
- Pre-evaluation based on basic technology and market criteria

»Level 3« - Enablers

- **~ 25 technology analyses** including market size and development, technological maturity, competitors etc.

➔ Selection of **10 Highlight enabling-technologies** based on market and technology fit criteria

Kick-Off Meeting

Workshop 1

Criteria-based (market and technology) priorization of market segments

(selection by participants)

Workshop 2

Criteria-based (market and technology) priorization of applications/ components

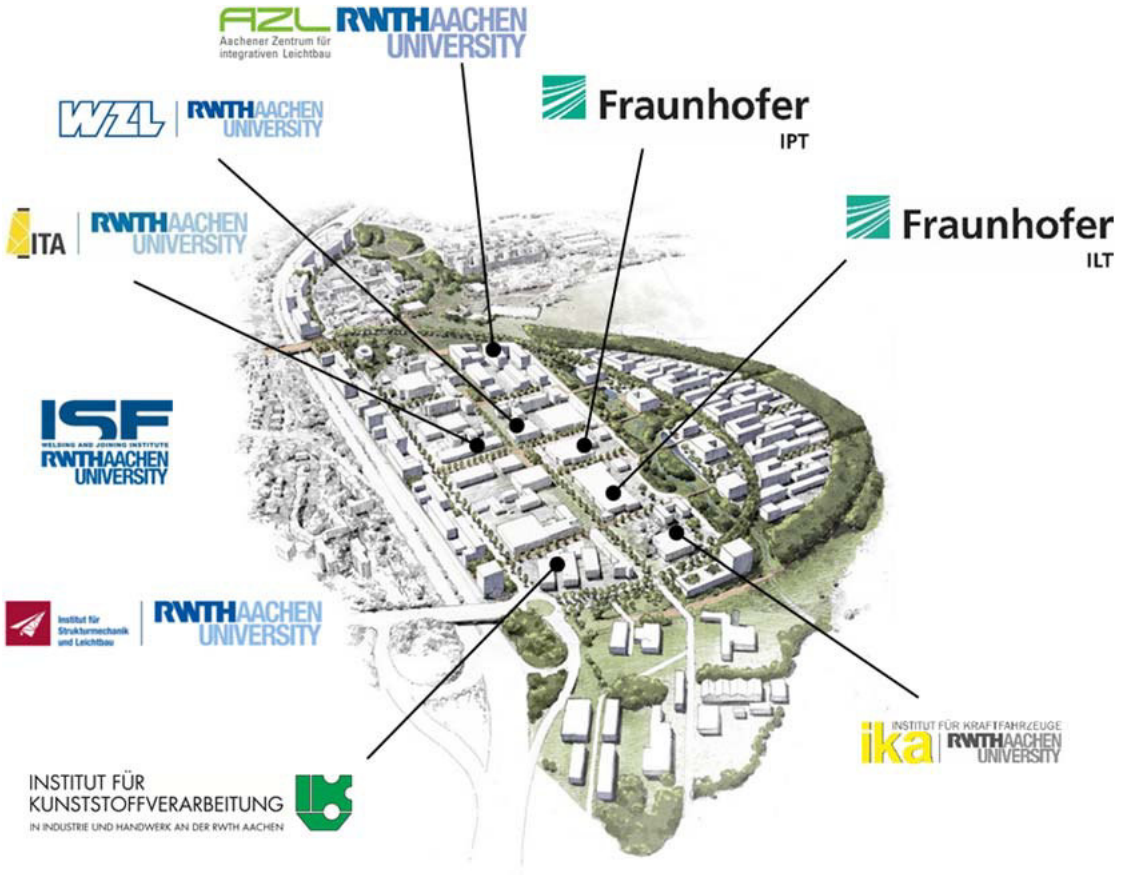
(Selection by Participants)

Final Meeting

Project Team Background: Competence Campus in Aachen

in cooperation with:

The project will be managed by AZL Aachen GmbH and conducted in cooperation with AZL partner institutes



Composite competences and cooperation since more than 25 years

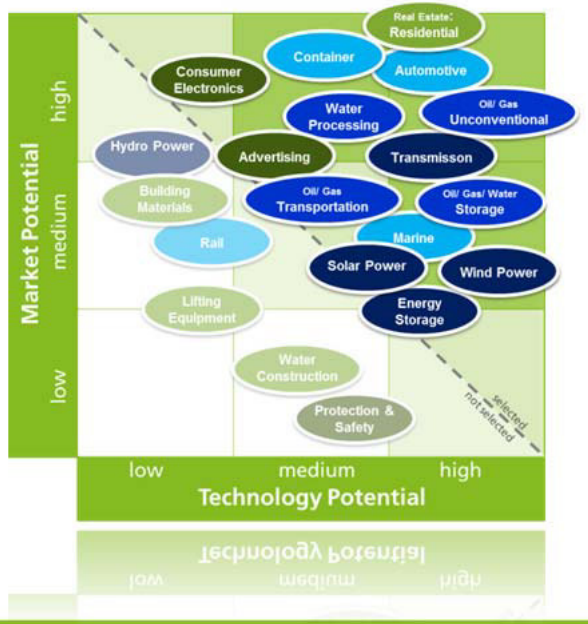
- Textiles (ITA)
- Plastics and Composites (IKV)
- Production Technology (AZL, WZL, IPT, ILT, ISF)
- Quality Assurance (WZL)
- Lightweight Design (IKV, SLA)
- Automotive (ika)

- 9 Institutes
- More than 750 scientists
- More than 1.100 student workers

Exemplary Proceeding

Stage 1 – Pilot Study

in cooperation with:
AZL Aachen GmbH
AZL Aachener Zentrum für integrativen Leichtbau
RWTH AACHEN UNIVERSITY



Market Segmentation

➔ Structured overview on market segments within „Buidlings & Infrastructure“, market structure and overall market volume

Segment Analysis

➔ Overview on high level chances, risks

➔ Technology and market trends

Segment Evaluation

➔ High level aggregation of market and technology intelligence

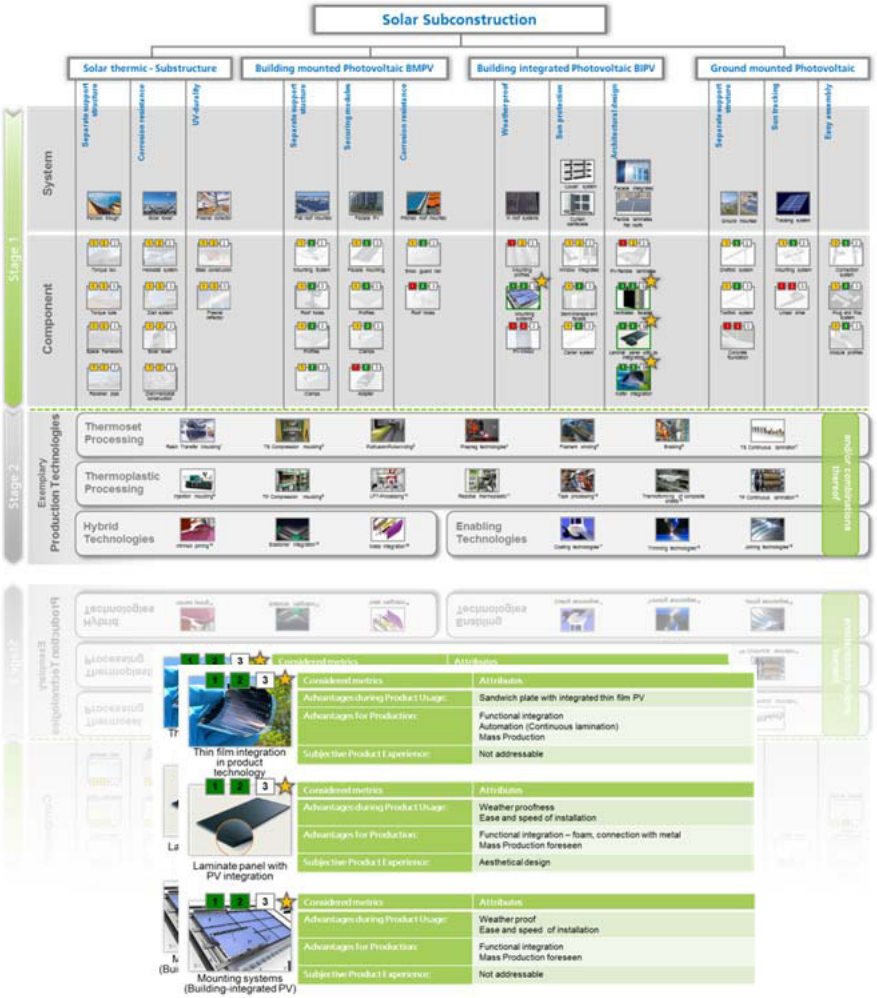
➔ Selection of most promising segments based on expert knowledge (interviews) and appraisal of the steering committee

Exemplary Proceeding

1 2 3

Stage 1 – Pilot Study

in cooperation with:



Segment Sub-structure

- Overview on technology fields within the market segment at hand

Detailed Segment Analysis

- Derivation of major challenges within these sub-segments in order to enable a focussed selection of growing or developing marketsegments

»Technology Tree«

- Market requirement-based breakdown of relevant sub-segments into systems and components

➔ Criteria-based (market and technology) priorization of applications/ components

Stage 2 – Detailed Analysis

Value-Chain Overview

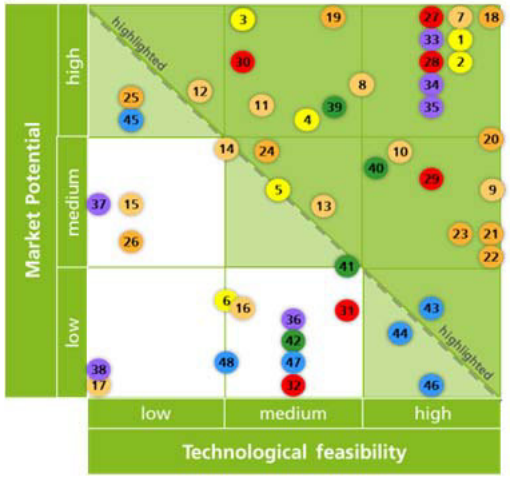
- Connected and/or synergetic technologies within the value-chain of the component at hand
- Visualization and quantification of added value steps and derivation of future requirements regarding material, process chains and production systems

Detailed Technology and Market Analyses

- Detailed Aggregation of relevant technology- and market-related information
- Executive Summary for quick evaluation
- ➔ Information basis for selection of highlight components/ applications

Exemplary Proceeding
Stage 3 – Business Cases

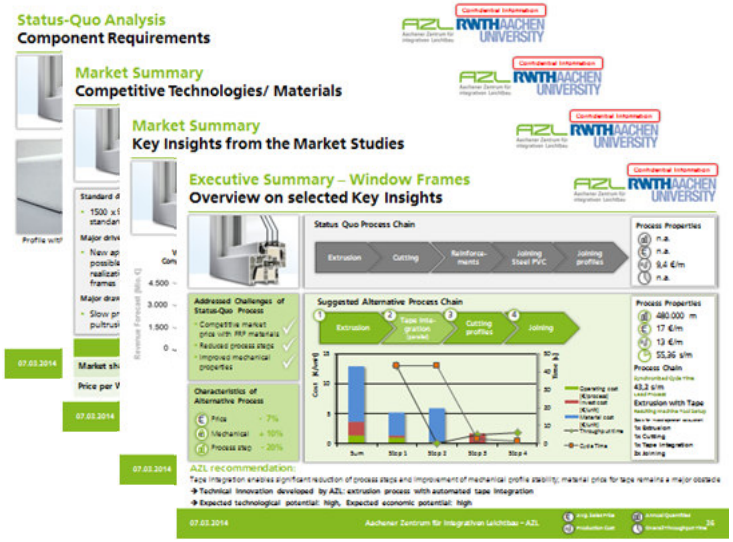
in cooperation with:
AZL Aachen GmbH
AZL Aachener Zentrum für integrativen Leichtbau
RWTH AACHEN UNIVERSITY



Application/ Component Selection

- Criteria-based portfolio analysis of remaining applications and components

➔ Final selection of 10 most promising highlight applications



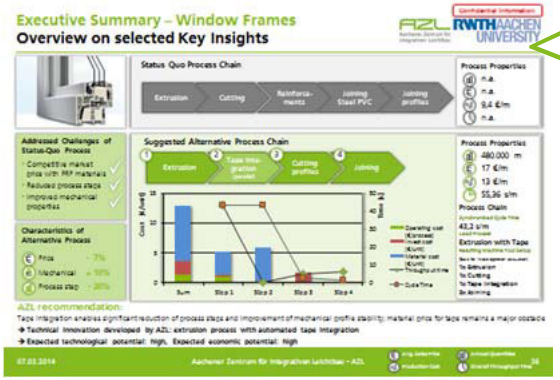
Business Case Analyses of selected Components

- Highly detailed calculation of business cases for the selected highlight applications/ components
- Derivation of relevant required technologies, materials and/or services to address these highlights

➔ Selection of most attractive components for further consortial projects and implementation

Exemplary Proceeding
Stage 3 – Business Cases

in cooperation with:



Part 1 – Executive Summary

Aggregation of component and process-related business case evaluations & **AZL-recommendations** for further pursuit

Part 2 – Market Summary

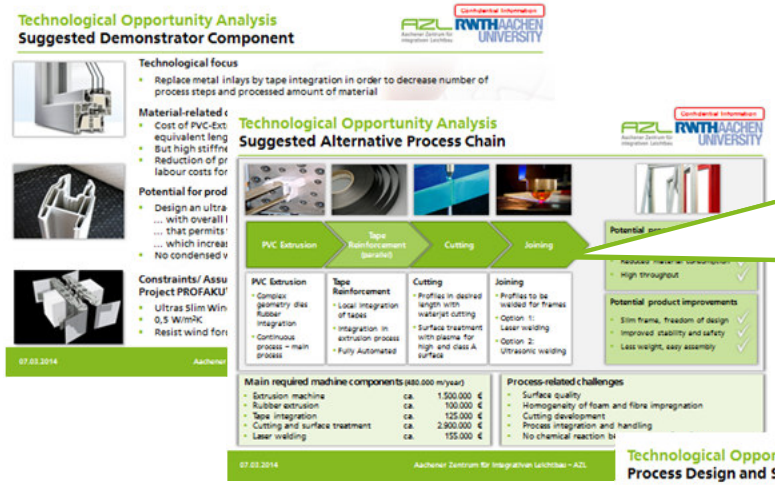
Detailed description of relevant market intelligence regarding the component & Overview on relevant **competitive technologies or materials**

Part 3 – Status-Quo Analysis

Intelligence on general requirements regarding the status-quo component (e.g. dimension, geometry, norms, etc.) & Overview on the **status-quo production process** including its properties and challenges

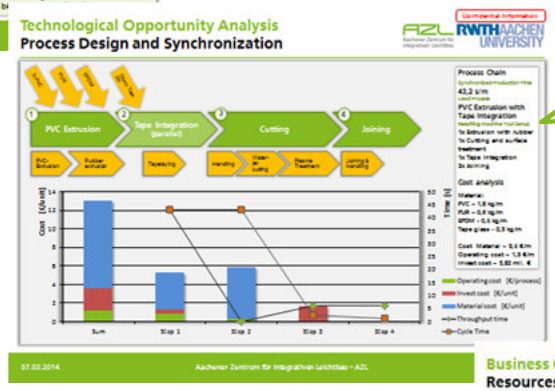
Exemplary Proceeding
Stage 3 – Business Cases

in cooperation with:



Part 4 – Suggested Alternative Demonstrator Process Chains

Detailed Description of a technologically feasible **demonstrator component** based on market requirements also considering potential improvements in product performance & component-related derivation and description of an **innovative process-chain**



Part 5 – Process Design

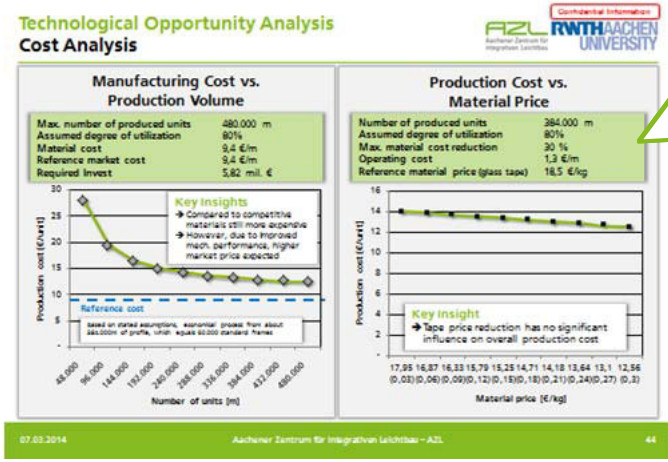
Description of the proposed process-chain including **process synchronization**, **machine tool set up** and **throughput analysis**

Part 6 – Resources

Exemplary Proceeding

Stage 3 – Business Cases – Cost Analysis

in cooperation with:

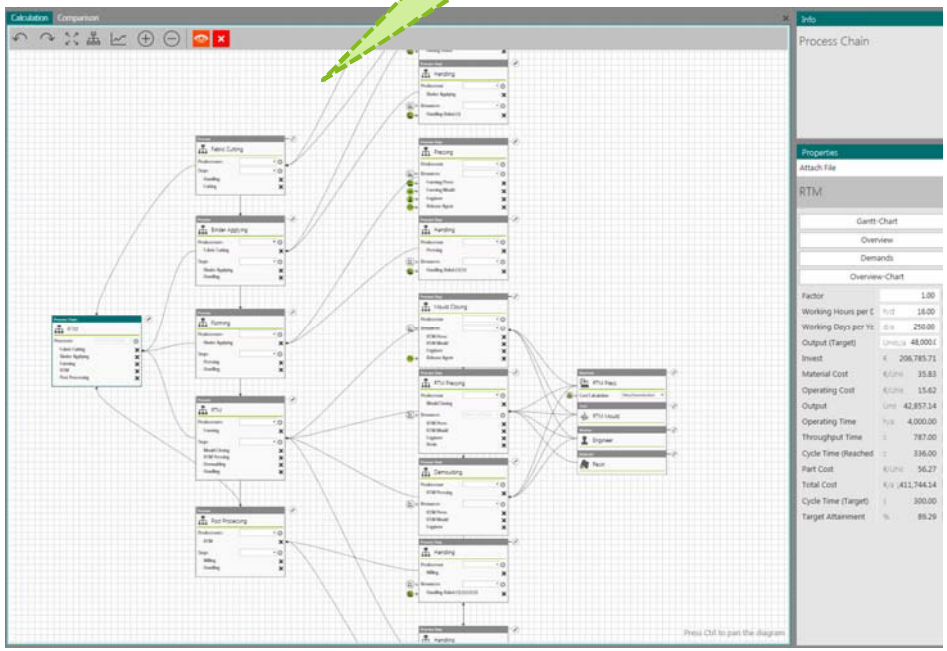


Part 7 – Cost Analysis

Visualization of relevant dependencies of production cost with production volume and material price for a **representative Business Case**

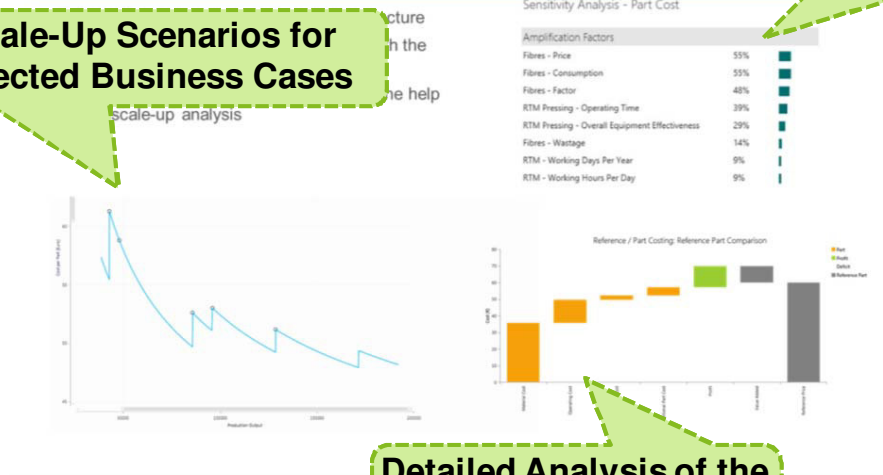
(**mass production conditions**: 3-shift 24h production, 240 productive days, 80% utilization, etc. – *case-specific exceptions*)

Detailed Process Cost Modelling for selected Business Cases (Cost, Cycle Times)



Sensitivity Analysis of Process Chain for selected Business Cases

Scale-Up Scenarios for selected Business Cases

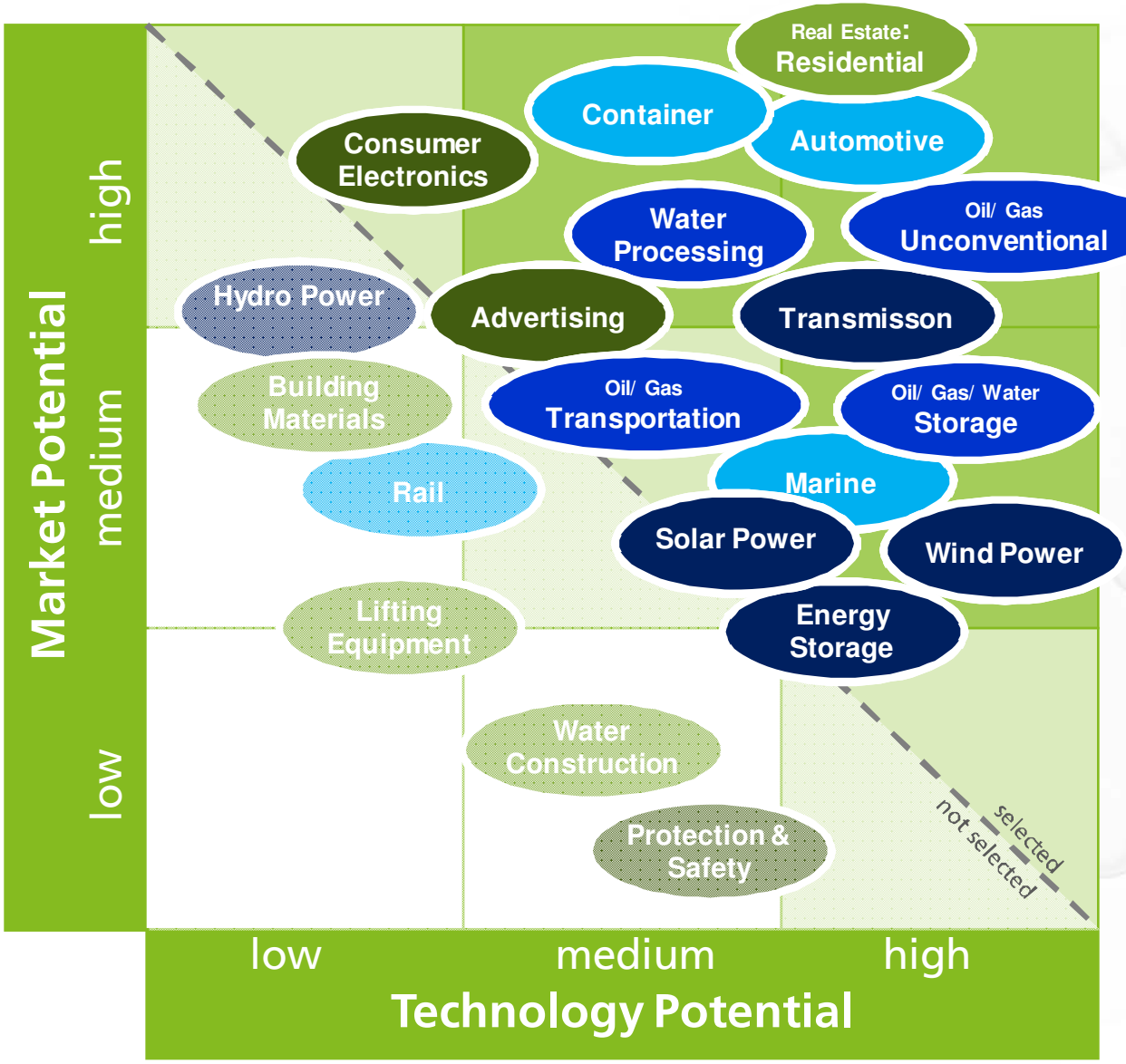


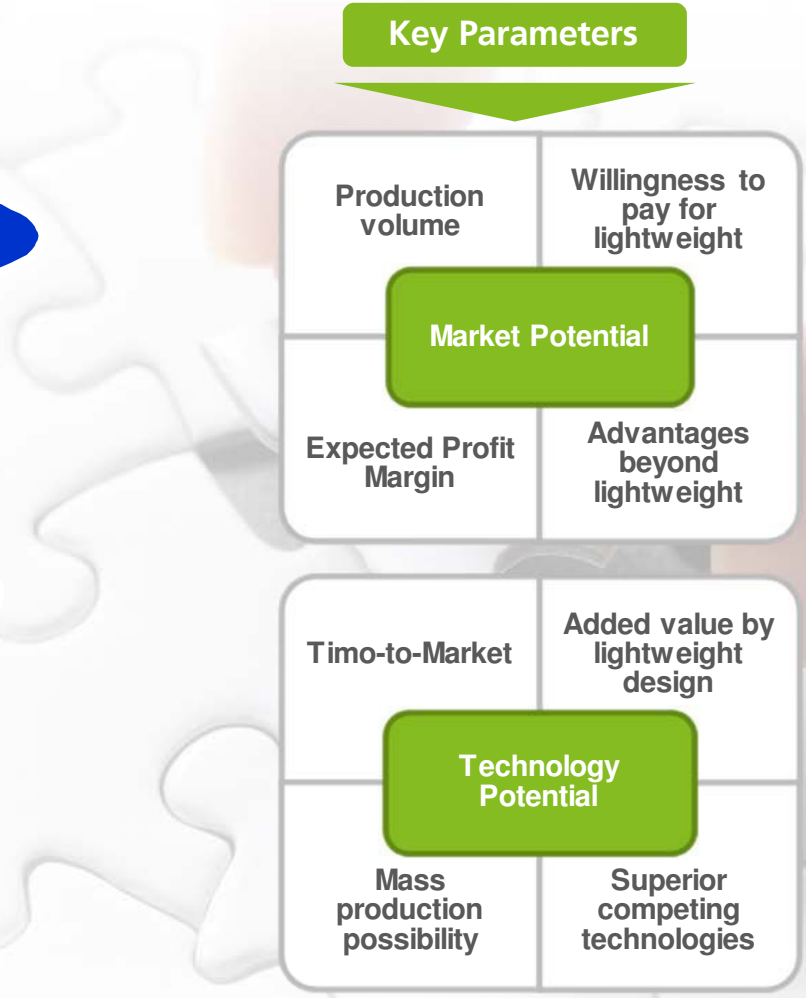
Detailed Analysis of the Cost Structure

»Worldwide Market Study for Lightweight Applications«

Highlight-Segment Evaluation Portfolio

in cooperation with:





Transportation
Oil, Gas & Water
Energy
Construction
Consumer Goods

How to read the »Technology Tree«
Overall Structure

in cooperation with:
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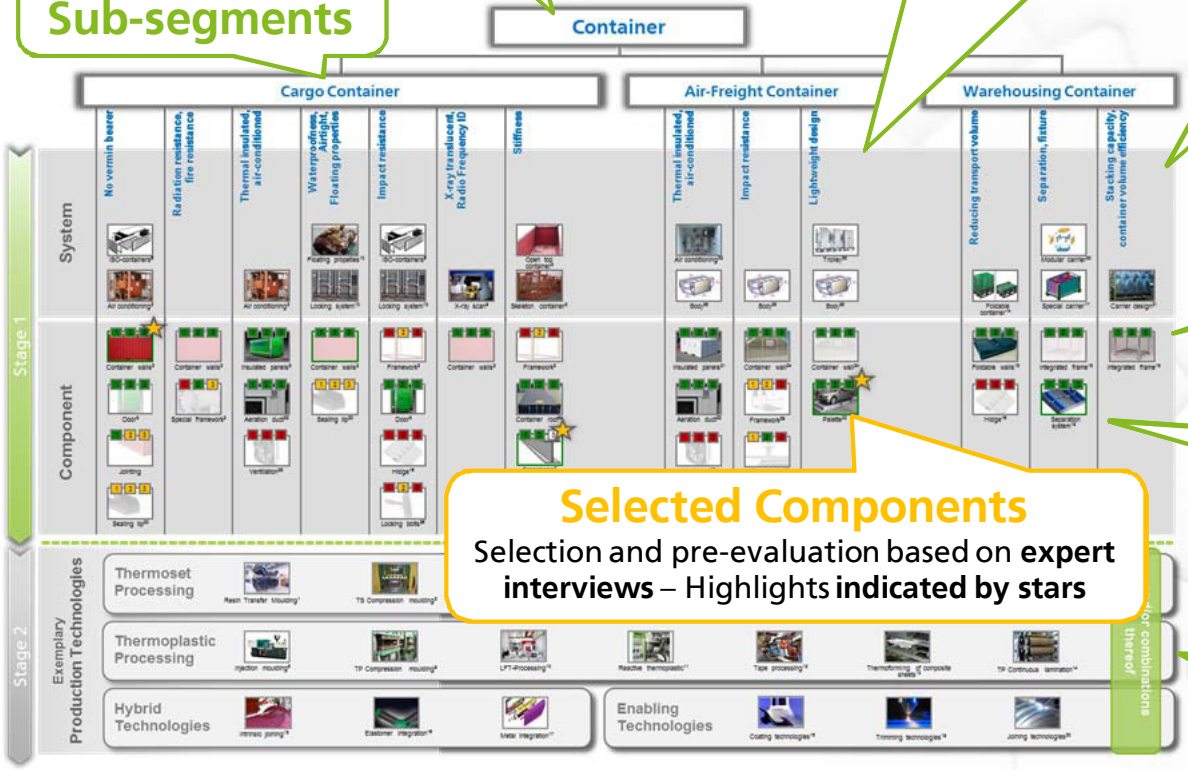
Segment
of interest

relevant
Sub-segments

Identified Challenges
basis for the **»branches«** of the Technology Tree

»System« Level
Aggregation of components (if applicable)

»Component« Level
relevant level for component selection, **Stage 2** of the market study will then comprise detailed market anlyses for selected components



Components
(pre-evaluated items of the technology tree, evaluation based on **3 basic evaluation criteria** indicating significant market potential, for evaluation criteria see next slide)

Selected Components
Selection and pre-evaluation based on **expert interviews** – Highlights **indicated by stars**

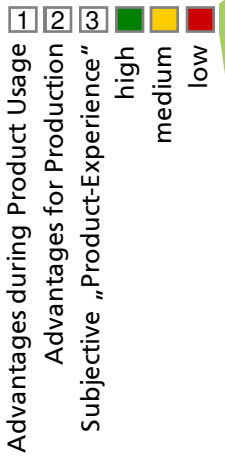
Exemplary Production Technologies
list of possible production technologies, that might enable cost-efficient and/or performance enhancing manufacturing of selected components - relevant for **Stage 2** of the market study, basis for discussion

Components marked with **faded colors** indicate that there are either **multiple entries** of the same component or that they are **considered within another Technology Tree** or that they are **not relevant** based on the pre-evaluation.

How to read the »Technology Tree«
Evaluation Logic

in cooperation with:

Potentials regarding:
(lightweight design, material properties)



1 Advantages during Product Usage

- **Mechanical**
  (e.g. increased load capacity, light weight performance, lower temperature warpage)
- **Chemical**
  (e.g. better corrosion properties, increased chemical resistance, biological compatibility)
- **Electrical**
  (e.g. tailored electrical properties)
- **Optical**
  (e.g. tailored optical structure and design surface)

2 Advantages for Production

- **Freedom of Design**
  (e.g. load adapted design)
- **Manufacturability**
  (e.g. estimated improved design/ performance by localreinforcements)
- **Process**
  (e.g. shorter cycle times, increased process robustness, automation possibility, possible mass-production)
- **Costs**
  (e.g. estimated performance gain over subsitutional material/ design going along with higher margin etc.)

3 Subjective Product-Experience

- **Subjective value**
  (e.g. willingness to pay more for the knowledge of utilizing lightweight components or innovative materials, prestige thinking)
- **Performance optics**
  (e.g. customer is willing to pay more for lightweight design like optics without real performance gain)
- **Perceived quality**
  (e.g. customer is willing to pay more for lightweight design like haptics, customer trust in high-performance etc.)

Elements not relevant for Evaluation (e.g. no subjective product value imaginable) will be left plain white

Construction - Selected Segments

Building Materials

Construction Equipment

Earthmoving

Lifting

Compacting

Transporting*

Civil Engineering

Road/Rail

Supply**

Water constr.

Special constr.

Real Estate

Residential

Non-residential

Industry

Facility Equipment

Water, Gas***

HVAC

Elevator****

* Considered in Transportation

** Considered in Energy and Oil, Water Gas

*** Considered in Oil, Water, Gas

**** Considered in Transportation

Civil Engineering: Residential

in cooperation with:

AZL Aachen GmbH — AZL Aachener Zentrum für integrativen Leichtbau — RWTH AACHEN UNIVERSITY

Evaluation Logic:

Potentials regarding:
(lightweight design, material properties)

1 2 3 high medium low

Advantages during Product Usage
Advantages for Production
Subjective „Product-Experience"

Technology Tree

Stage 1

Stage 2

Civil Engineering: Residential

Smart/Green Building

Energy efficient cladding
- System: Cladding as design
- Component: Kinetic wind cladding; Air condition claddings; Back ventilated cladding; Substructure cladding[4]

Insulation and photovoltaic integration
- System: Energy consumption
- Component: Insulation panel[1]; Ultraslim window; Photovoltaic integration; Energy saving window

Smart housing
- System: Smart housing
- Component: Control panels; Security System; Wall integrated touchscreen; Smart metering

Intelligent lighting
- System: Intelligent lighting
- Component: O-LED ceiling integration; Roof windows; Sun protection[2]; Ultraslim window

Design flexibility
- System: Temporary building
- Component: Lighting cladding; Tex glass elements; Glass reinforced cladding

Affordable Houses and Prefabricated Houses

Ease of transportation
- System: Fold away houses
- Component: Expandable shelter; Building set houses; ISO shipping container; Parking decks

Ease and speed of assembly
- System: Temporary building
- Component: Building superstructure; Exterior/Interior wall; Roofing systems; Modular walls

Reduced construction costs
- Component: Foldable structure; Sandwich cladding; Door systems; Blast protection

Mass Customization
- Component: Building Information Model; Loft cube – Modular living

Innovative Building Concepts

Mini houses
- System: Loft cube mobile houses; Minimum impact houses
- Component: Glass reinforced cladding; Steel frame construction; Modular walls

Floating houses
- System: Floating houses
- Component: Floating pontoons; Lightweight construction; Sandwich cladding

Recycled houses
- System: Recycled houses
- Component: Steel frame construction; Back ventilated cladding; Kitchen-recycled advertising panels

Modular houses
- System: Modular houses[17]
- Component: Room units[20]; Aluminium systems[8]; Sliding walls[11]; Modular walls[10]

Exemplary Production Technologies

Thermoset Processing
- Resin Transfer Moulding[1]
- TS Compression moulding[2]
- Pultrusion/Pullwinding[3]
- Prepreg technologies[4]
- Filament winding[5]
- Braiding[6]
- TS Continuous lamination[7]

Thermoplastic Processing
- Injection moulding[8]
- TP Compression moulding[9]
- LFT-Processing[10]
- Reactive thermoplastic[11]
- Tape processing[12]
- Thermoforming of composite sheets[13]
- TP Continuous lamination[14]

Hybrid Technologies
- Intrinsic joining[15]
- Elastomer integration[15]
- Metal integration[16]

Enabling Technologies
- Coating technologies[17]
- Trimming technologies[18]
- Joining technologies[19]

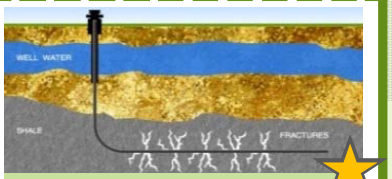
and/or combinations thereof

Oil, Gas and Water – Selected Segments

Transportation ★

Oil/gas production

Conventional oil / gas



Unconventional oil / gas ★

Processing

Oil, gas processing

water processing ★

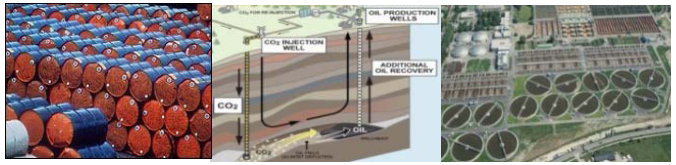
Storage for usage

High pressure applications

Applications for chemicals ★

Usage

Recycling & Disposal



Transportation and **Storage** are combined in one technology tree due to large application similarities (mainly pipes and tanks)

in cooperation with:

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Transportation and Storage of Oil, Gas and Water

Evaluation Logic:

Potentials regarding:
(lightweight design, material properties)

1 2 3 high medium low

Advantages during Product Usage
Advantages for Production
Subjective „Value-Experience"

Technology Tree

Stage 1

Components/ Systems

Transportation and Storage of Oil, Gas and Water

Onshore Pipeline

Low thermal distortion/lengthening and fire safe design
- Onshore pipe segments
- Valves
- Above-ground fastening structures
- Flanges
- Clamps
- Expansion compensator
- Onshore pipe coatings

High mobility of pipes
- Handling and positioning
- Flexible Pipes
- Coiled pipeline
- Installation radius
- Packaging systems

Safe operation in territories with climatic fluctuation and environmental changes
- Fire safe materials
- Above-ground fastening structures
- Underground fastening structures
- Continuous pipes with discontious wal thickness and diameter
- Onshore pipe coatings
- Pipeline joints

Offshore Pipeline

Prevention of corrosion, due to internal and external influences
- Stringer system
- Offshore pipe systems
- Concrete substitution
- Arcs
- Weld joint insulation
- Pipeline joints

Ensuring and monitoring leakproofness of the pipeline
- Safety valves
- Decoupling system
- Pipeline inspection gauge (PIG)
- Safety seals
- Pipe sensors (optical, acustical, thermal)

Minimizing erosion and friction for the transport of heavy oil or gas/oil/sand mixtures
- Long distance pumps
- Offshore pipe systems
- Arcs
- Seals
- Anti-friction layer

Advancing the resistance against mechanical stresses
- Flexible pipes
- Offshore pipe systems
- Floating structures
- Special ropes
- Arcs
- Titanium fasteners
- Pipeline joints

Fast, repeatable and risk free assembly and ability for repair
- Underwater welding systems
- Underwater robots
- Underwater positioning systems
- On sea pipe repair tools
- Titanium fasteners
- Pressure Isolation during repair

Storage for Oil and Gas

Advancing the pressure and impact resistance
- Vessel system
- Tank coating
- Tank liner
- Pressure gauges

Ensuring chemical resistance
- Oil barrels
- Mobile Poseidon tanks
- Mobile frac tanks
- Titanium elements
- Tank valves
- Tank liner
- Winding and fil port

Meeting the security-standards (Gas – explosion risk; oil – blockage, fire risk)
- Oil trains
- Double hull oil tanker
- Pipe strainer
- Safety valve
- Tank level gauges1

Withstanding pressure peaks and ensuring progressive failure modes
- LNG vessels on tanker
- Safety valve
- Tank coating
- Expansion compensator

Storage for Water

Increasing the resistance against acids and brines
- Vessels
- Tank joints
- Tank liner
- Winding and fil port

Ensuring the standards for potable water
- Felxible potable water tanks
- Potable water tank
- Pumps for potable water
- Tank liner
- Tubes / pipes for potable water

Stage 2

Exemplary Production Technologies

Thermoset Processing
- Resin Transfer Moulding[1]
- TS Compression moulding[2]
- Pultrusion/Pullwinding[3]
- Prepreg technologies[4]
- Filament winding[5]
- Braiding[6]
- TS Continuous lamination[7]

Thermoplastic Processing
- Injection moulding[8]
- TP Compression moulding[9]
- LFT-Processing[10]
- Reactive thermoplastic[11]
- Tape processing[12]
- Thermof orming of composite sheets[13]
- TP Continuous lamination[14]

Hybrid Technologies
- Intrinsic joining[14]
- Elastomer integration[15]
- Metal integration[16]

Enabling Technologies
- Coating technologies[17]
- Trimming technologies[18]
- Joining technologies[19]

and/or combinations thereof

Unconventional Oil and Gas (Extraction and Production)

in cooperation with:

AZL Aachen GmbH | AZL Aachener Zentrum für integrativen Leichtbau | RWTH AACHEN UNIVERSITY

Evaluation Logic:

Potentials regarding:
(lightweight design, material properties)

1 2 3 high medium low

Advantages during Product Usage
Advantages for Production
Subjective „Value-Experience"

Technology Tree

Unconventional Oil and Gas (Extraction and Production)

Hydraulic Fracturing („Fracking")

Oil Sands

Ultra Deepwater Oil Extraction

Stage 1 – Components/ Systems

Increasing chemical resistance of storetanks	Monitoring and counter measure in case of leakage	Minimizing erosion (quartz sand)	Comply with security standards for operation and material	Maximize percentage of pumped out chemicals	Cost-saving and fast installation of production site	100% leak proofness of very poisonous process waste	Better processing of efficient heavy oil extraction	Fast, repeatable and risk-free assembly and construtions	High temperature gradients	Disaster management and firesafe design	Reduction of weight at top side structures	Increasing internal and external pressure resistance	Reduction of corrosion (ice wedging or reaction of seawater with metal)	Increasing material performance for deep drilling and strong water movements in arctic conditions
Waste water tank	Monitoring station	Case pipes	Case pipes	Case pipes	Case pipes	Case pipes	Case pipes	Platform construction	BOP	Platform	Accomodation	Platform	Drilling system
Poseidon tank	BOP	Mud pump	BOP	Frac pump	Derrick tower	Catch basin	Upgrader	Seaf loor platform	Drilling system	BOP	Derrick tower	Hydraulic pump	Ships	Remote acoustic release
Collapsible frac tank	Lubricator	Connections	Tanks	Manifold	Housing complexes	Tanks	Pumps	Subsea pump	Riser	Insertion tube	Stairs	Riser	Subsea pump	Connections
Flow-Back tank	Pipe control	Redirecting pipe end	Well casing	Valves	Heavy tools		Flat conveyor	Conductor pipe	Annular prev enter	Ladders	Gooseneck	Riser	
Tank-accessories	Valves	Mud v alves	Bridge plug	Coupling systems				Ropes	Blind Shear ram	Decks	Pressure seal	ROV	
	Gauge		Rotary table					Cables*	Titanium elements	Pipe ram	Catwalks		Case pipes	Titanium elements

Stage 2 – Exemplary Production Technologies

Thermoset Processing	Resin Transfer Moulding[1]	TS Compression moulding[2]	Pultrusion/Pullwinding[3]	Prepreg technologies[4]	Filament winding[5]	Braiding[6]	TS Continuous lamination[7]
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Hybrid Technologies	Intrinsic joining[14]	Elastomer integration[15]	Metal integration[16]				
Enabling Technologies	Coating technologies[17]	Trimming technologies[18]	Joining technologies[19]				

and/or combinations thereof

Seawater Desalination

in cooperation with:

AZL Aachen GmbH — AZL Aachener Zentrum für integrativen Leichtbau — RWTH AACHEN UNIVERSITY

Evaluation Logic:

Potentials regarding:
(lightweight design, material properties)

1 2 3 high medium low

Advantages during Product Usage
Advantages for Production
Subjective „Value-Experience"

Technology Tree

Seawater Desalination

Thermal Processes

Lowering erosion and corrosion of heat exchangers, pumps and shells
- Heat exchangers
- Brine heater
- Casing
- Heat exchange tubes (titanium)
- Pelton wheel
- Flash chamber
- Pumps

Increase of efficiency due to higher temperature levels
- Condenser tubes
- Butterfly valves
- Ball Valves
- Brine chamber
- Demister

Feasibility for mobile applications
- Mobile desalination units
- Desalination containers
- Brine discharge
- Solar panel frames*
- Tanks
- Pipes
- Manifolds

Prevention of corrosion in structures
- Pipes
- Tanks
- Vessels
- Spray aeriation
- Handrails
- Ladders
- Wireway

Easy and leak-proof repair as well as replacement of damaged parts
- Blades
- Pipes
- Chambers
- Manifolds

Efficient and low-wear operation of pressure generators
- Huge turbines
- H. performance compressors
- Blades
- Steam Jet Ejectors

Resistant and durable intake systems
- Underwater pumps
- Seawater pipes
- H. Performance Valves

Resistant and durable Brine Outlet
- Discharge diffuser
- Pipes
- Offshore pipes
- Low corrosion pumps
- Low corrosion valves

Ensuring the standards of potable water
- Clean water pipes
- Pumps for potable water
- Clean water filters

Membrane Processes

Feasibility for mobile applications
- Frames
- Containerized RO
- RO modules
- Connectors
- Tanks
- Pressure vessels
- Pumps

Increase of efficiency
- Energy recovery turbine (SS 2507)
- Pressure exchanger
- RO module
- Membrane system
- Frames

Prevention of corrosion in storage and transportation systems
- Pipes
- Tanks
- Vessel
- Pressure vessel
- Manifolds
- Electrodes
- Pumps

Safe operation at High pressure levels
- RO modules
- H. performance compressors
- Pressure vessel
- Thrust Collar
- Filter connectors
- RO Filter parts
- RO Connectors

Ensuring the standards of potable water
- Clean water pipes
- Pumps for potable water
- Clean water filters

Resistant and durable Brine Outlet
- Discharge diffuser
- Floating pipes
- Brine pumps
- Pelton wheel
- Brine outlet
- Brine pipes
- Brine valves

Stage 1: Components/ Systems

Stage 2: Exemplary Production Technologies

Thermoset Processing
- Resin Transfer Moulding[1]
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and/or combinations thereof

Technologically similar components are summarized to according groups (e.g. valves)

Highlights - Residential

Sun Protection

Considered metrics	Attributes
Advantages during Product Usage:	Due to anisotropy – adaptable without propulsion Easy and light assembly
Advantages for Production:	Freedom of design Improved perfomance by local reinforcement
Subjective Product Experience:	Unexpected performance Aesthetic design

Expandable shelter

Considered metrics	Attributes
Advantages during Product Usage:	Easy and fast assembly, less space in transport needed corrosion resistance
Advantages for Production:	Functional integration of connection system Thermal and accoustic insulation Local reinforcement of panels etc
Subjective Product Experience:	Not addressable

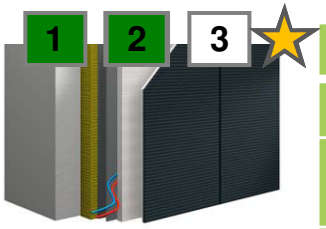
Room units

Considered metrics	Attributes
Advantages during Product Usage:	Ease of transport and assembly High mechanical strengths
Advantages for Production:	Freedom of Design Functional integration
Subjective Product Experience:	Not addressable

Highlights - Residential

Ultraslim window

Considered metrics	Attributes
Advantages during Product Usage:	Small frame brighter glass area similar thermal expansion to glass
Advantages for Production:	Functional integration – foam, connection, Automation possible
Subjective Product Experience:	Small frame as subjective value Customer trust in high performance of material



Considered metrics	Attributes
Advantages during Product Usage:	Easy and light assembly, corrosion resistance
Advantages for Production:	Freedom of design – archictectural application Functional integration of e.g. PV wafer
Subjective Product Experience:	Aesthetical design

Back ventilated cladding with substructure

Your Contact

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