



heating science



innovation.is.real

smart innovation – Technik von morgen

Printed Electronics in Automotive applications. Challenges and Opportunities.

Christian Kussmann

LOPEC, February 2023



PRESENTER

Christian Kussmann

I am one of the co-founders and Chief Technology Officer of ATT. With 20 years of experience in the Automotive and Aerospace industries, including 15 years as an entrepreneur, I have primarily focused on thermal management, thermal comfort, and the electrification of vehicles. Our efforts since 2014 have been directed towards translating our ideas and vision in context of printed electronics into products that cater to future markets.



ATT and Printed Electronics

Who we are and what Printed Electronics means for us (4)



Innovation vs Printed Electronics

Is Innovation a guarantee for Success? What means Innovation, what challenges to we face in Automotive Industry? (8)



Use Cases utilizing Printed Electronics

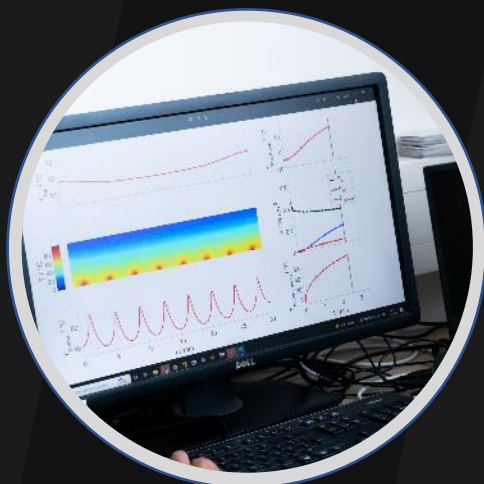
Introduction to different use-cases relating to innovation and the corresponding challenges (8)



Challenges & Opportunities

Summary (1)

ATT and Printed Electronics



Printed Electronics Solutions (Automotive)

Printed Flexible PTC-Heaters
Printed Flexible Sensors
Electronics

Battery Thermal Management
Thermal Comfort Optimization
ADAS Sensor & Camera Heating Systems
Flexible Printed Circuits (FPCs)
Sensors
Fluid Heaters

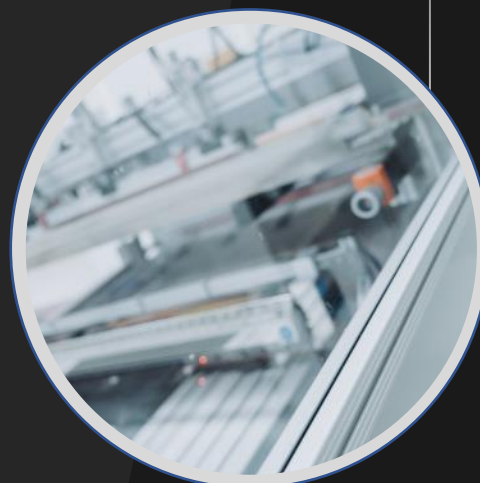


Product Development

Development of Specifications
A-Sample
B-Sample
C-Sample / Industrialization / Validation/ Qualification
Certification

Manufacturing

Prototyping
Series Manufacturing (up to 200.000 m² pA)



We are a **solution provider, developer and manufacturer** of **intelligent heating & sensing systems in the field of printed electronics.**

We support our customers in specifying what they need, deliver prototypes in a very short time and beyond that we can also offer series parts.

ISO 9001:2015
qualified for EN 9100:2018 & EASA Part 21G
qualified for IATF 16949



ATT and Printed Electronics

We have a strong focus on Automotive industry, because that is where most of us come from. But our technologies and products can be used in many other industries as well. We see ourselves as solution providers and our technologies get integrated into a wide range of different applications.

AUTOMOTIVE

50%

AEROSPACE

20%

RAILWAY

15%

LIFE SCIENCE

10%

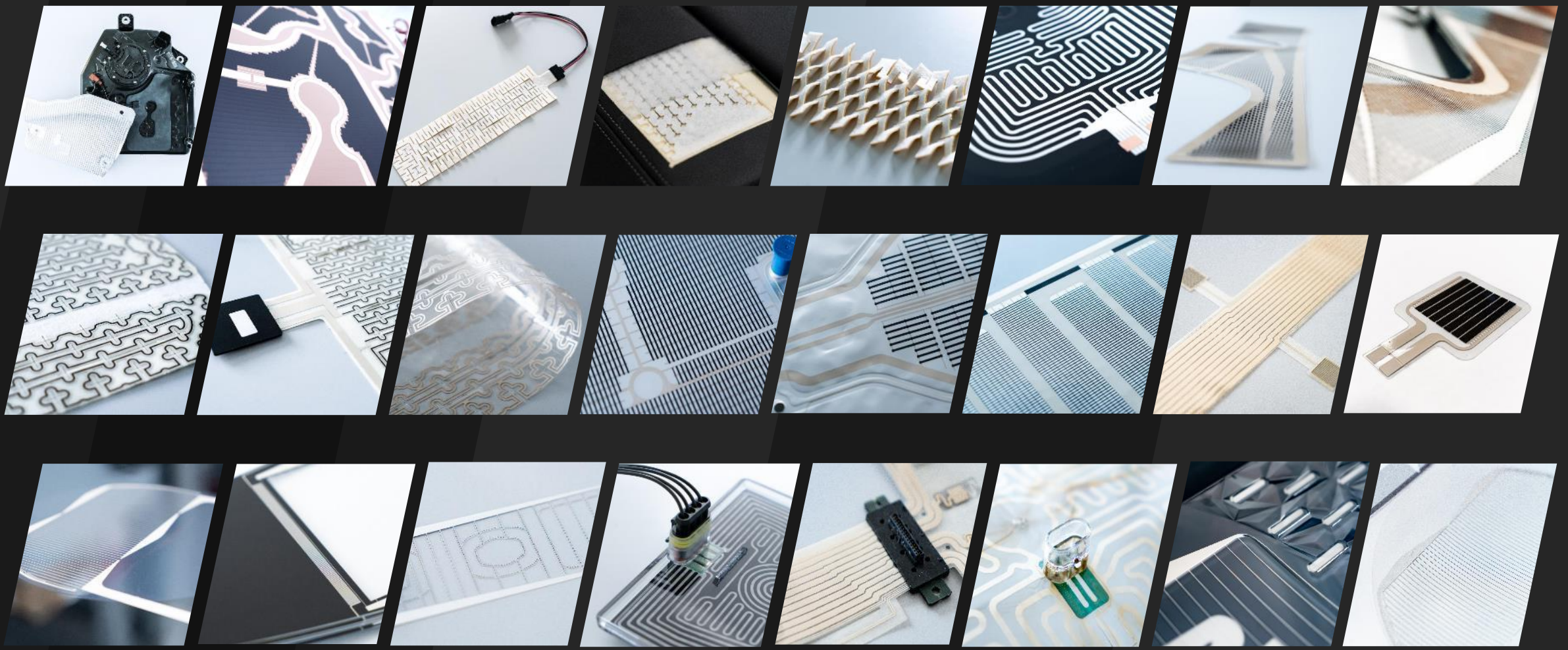
DEFENCE

5%

ATT and Printed Electronics



What Printed Electronics means for us





■ Innovation vs Printed Electronics

Innovation is the process of creating something new and valuable that has the potential to positively impact and improve people's lives.

ChatGPT 2023

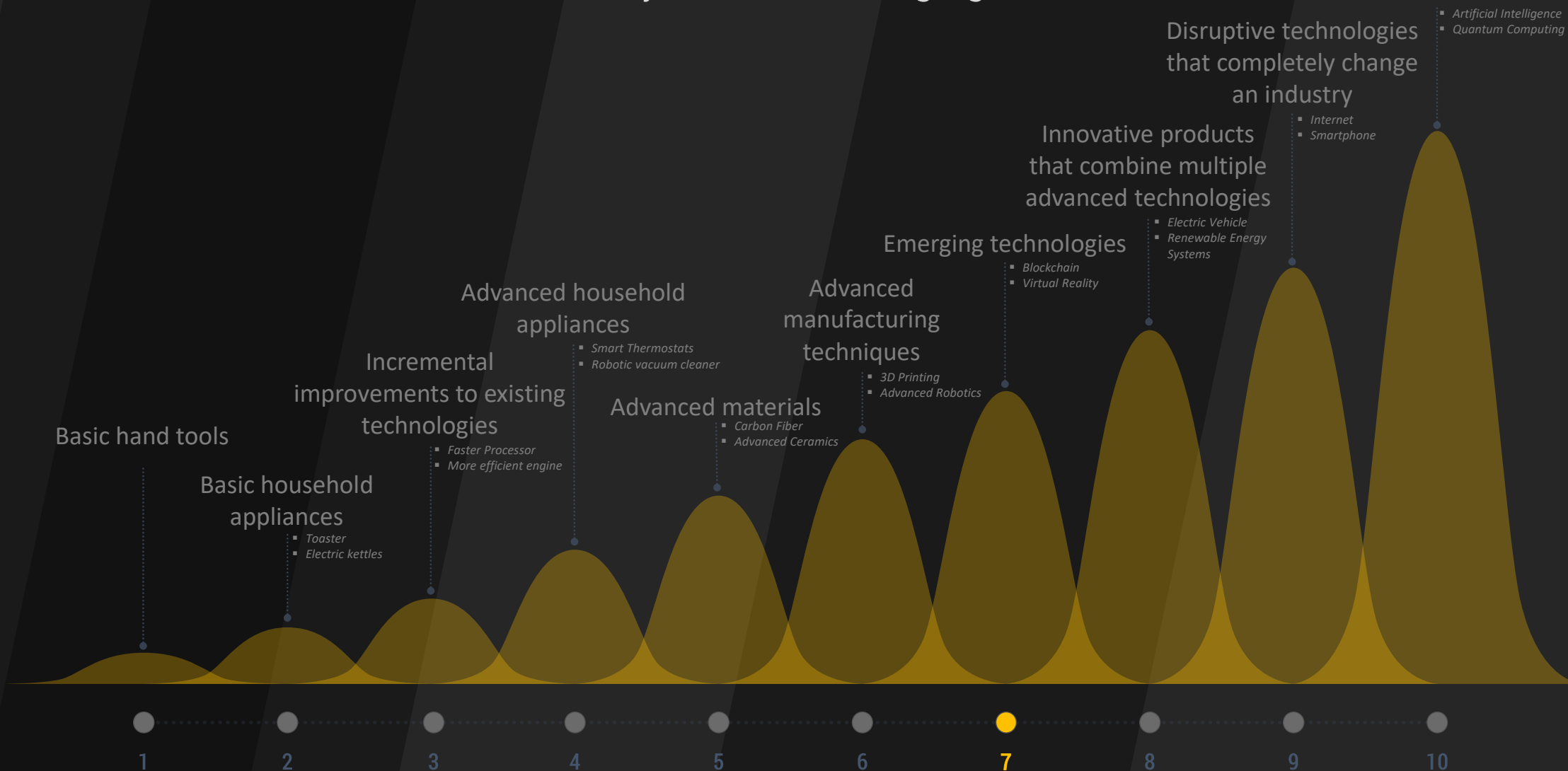


■ Innovation vs Printed Electronics

Innovation in the Automotive Industry can be defined as the process of introducing new technologies or methods that have the potential to reduce costs, improve performance, and meet the changing needs of customers.

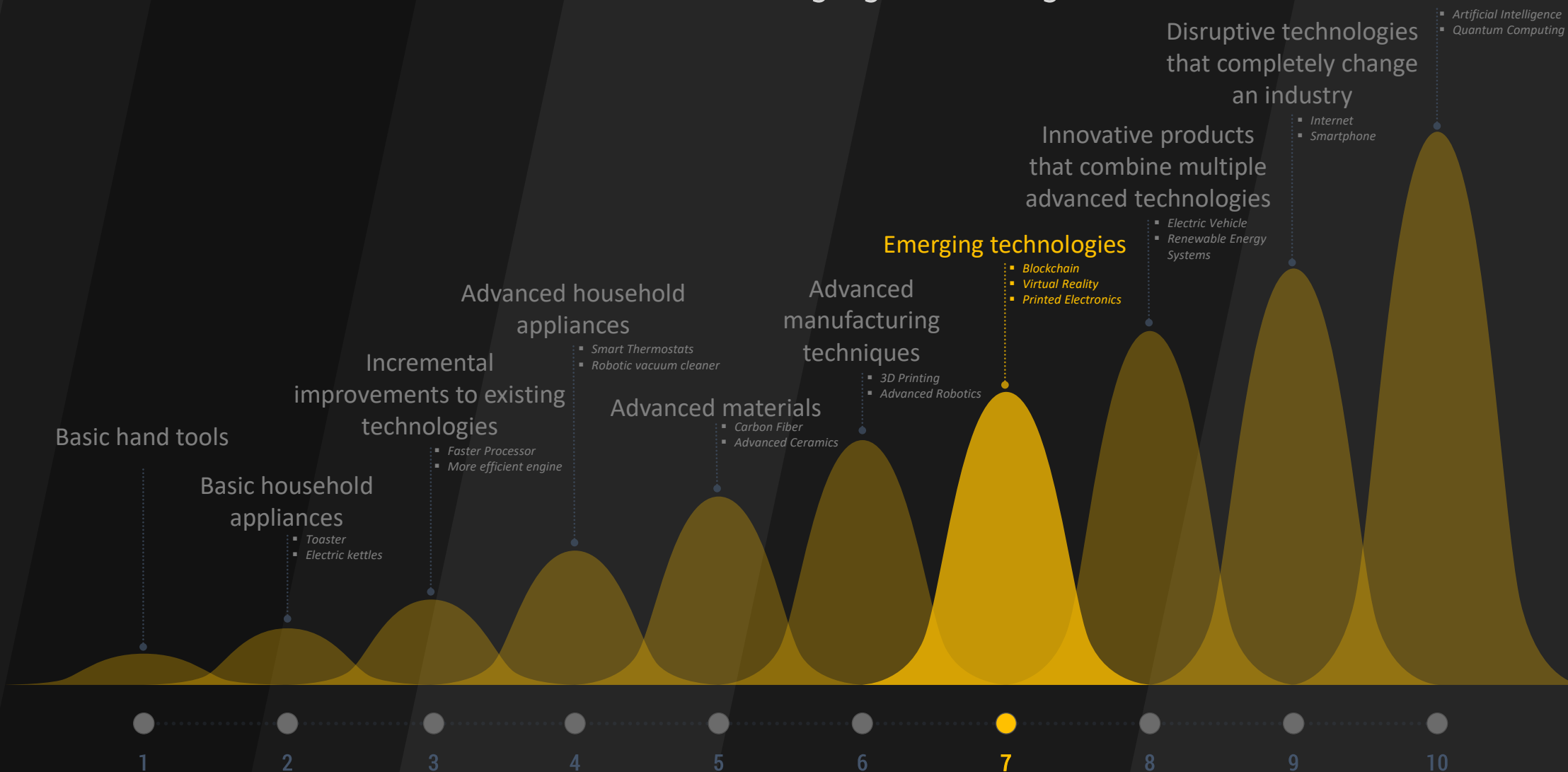
Innovation vs Printed Electronics

The Innovation Scale: From Commodity to Game-Changing



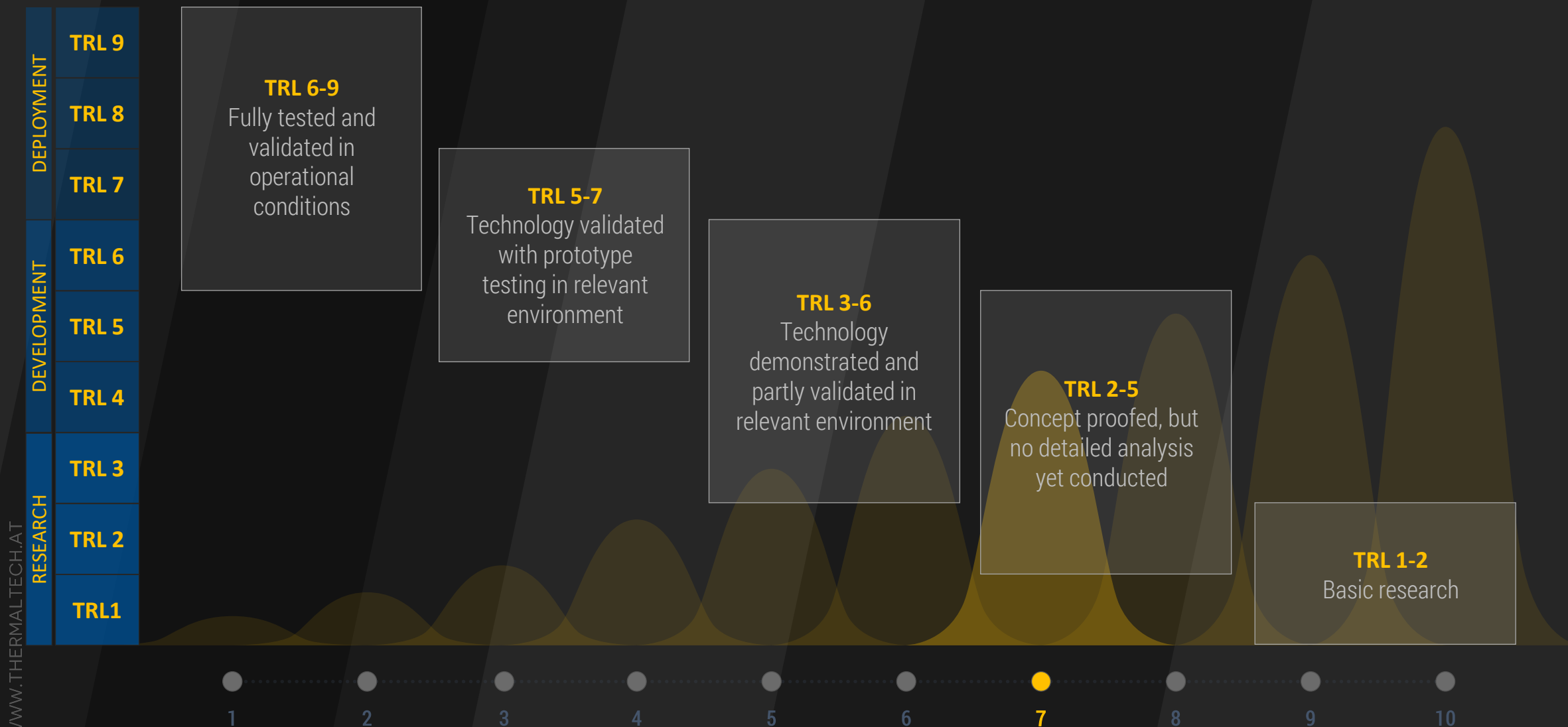
Innovation vs Printed Electronics

The Innovation Scale: Printed Electronics / Emerging technologies



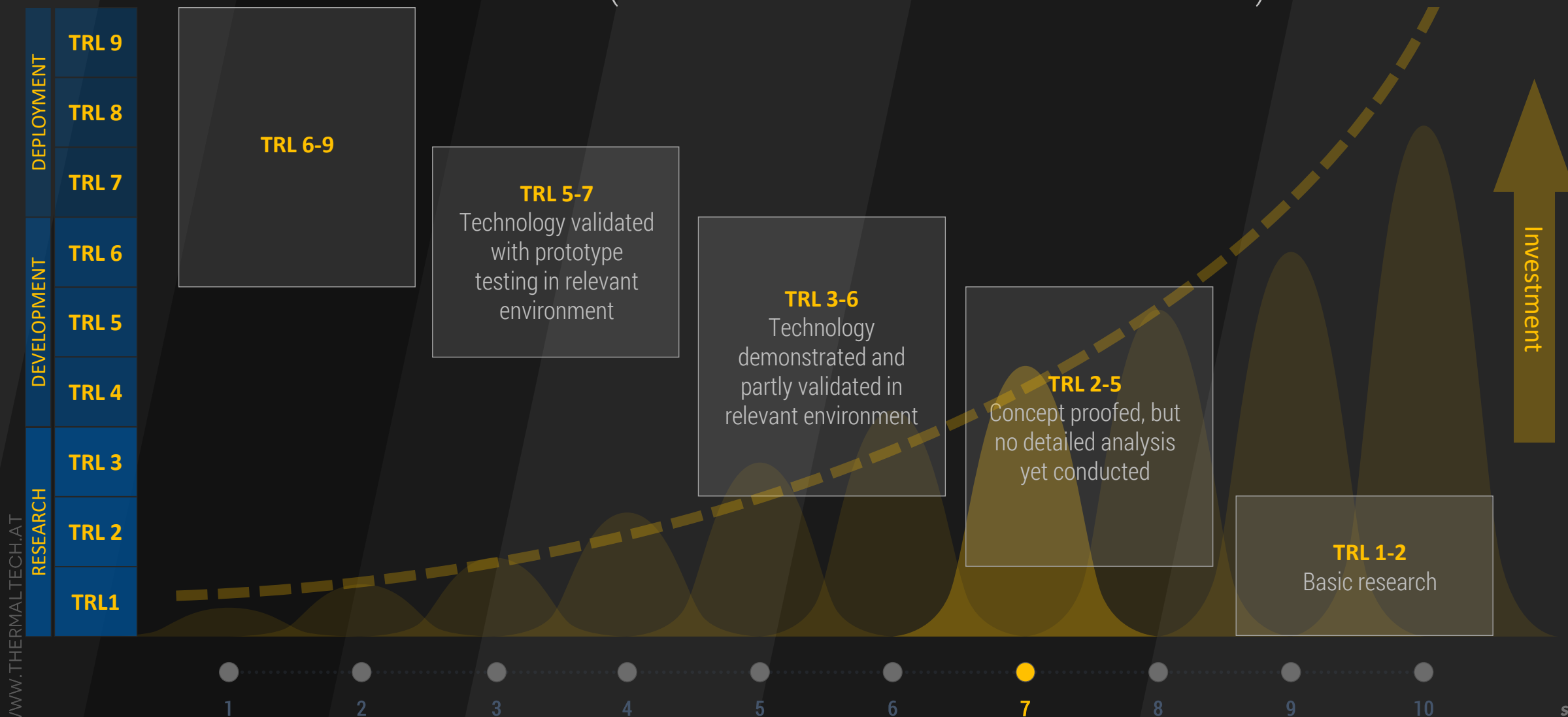
Innovation vs Printed Electronics

Innovation Scale vs TRL



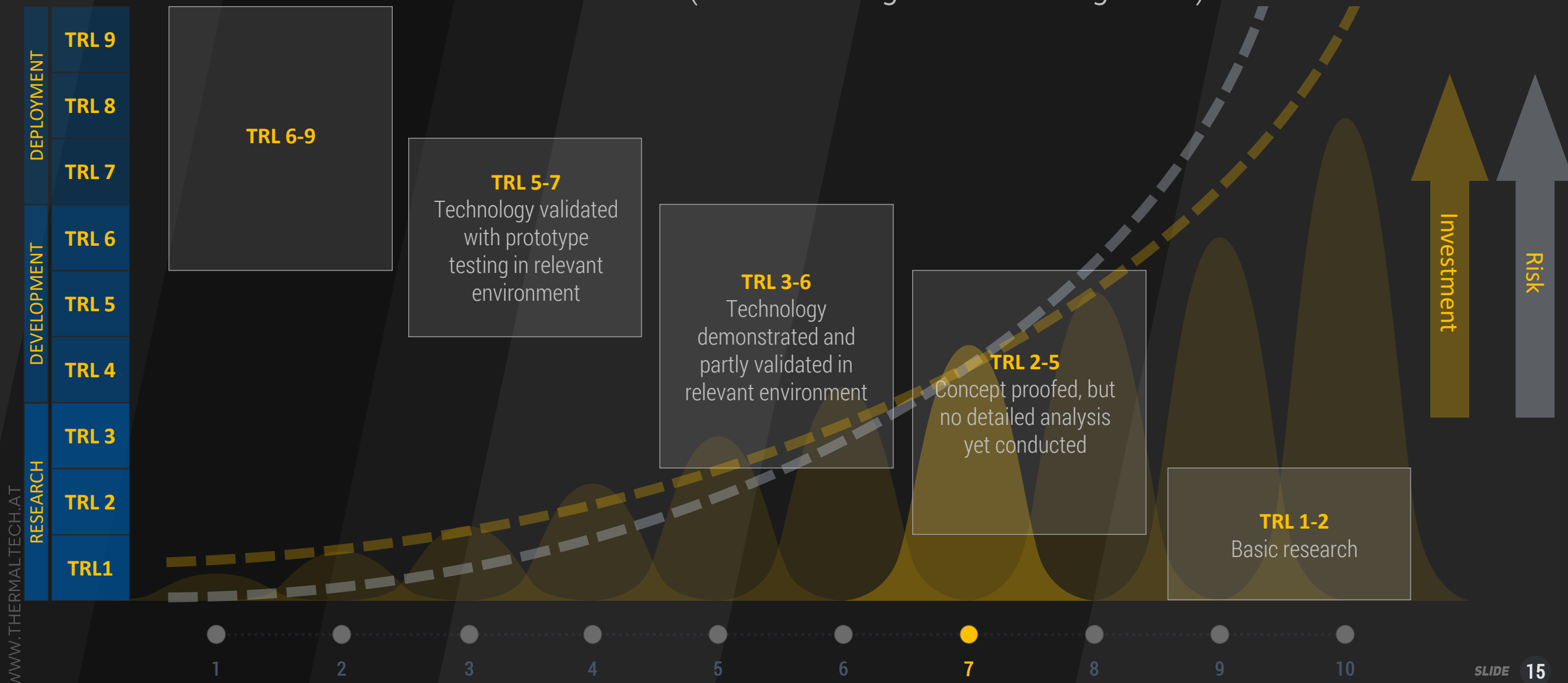
Innovation vs Printed Electronics

Innovation vs TRL vs Investment (cost of commercialization to reach TRL9)



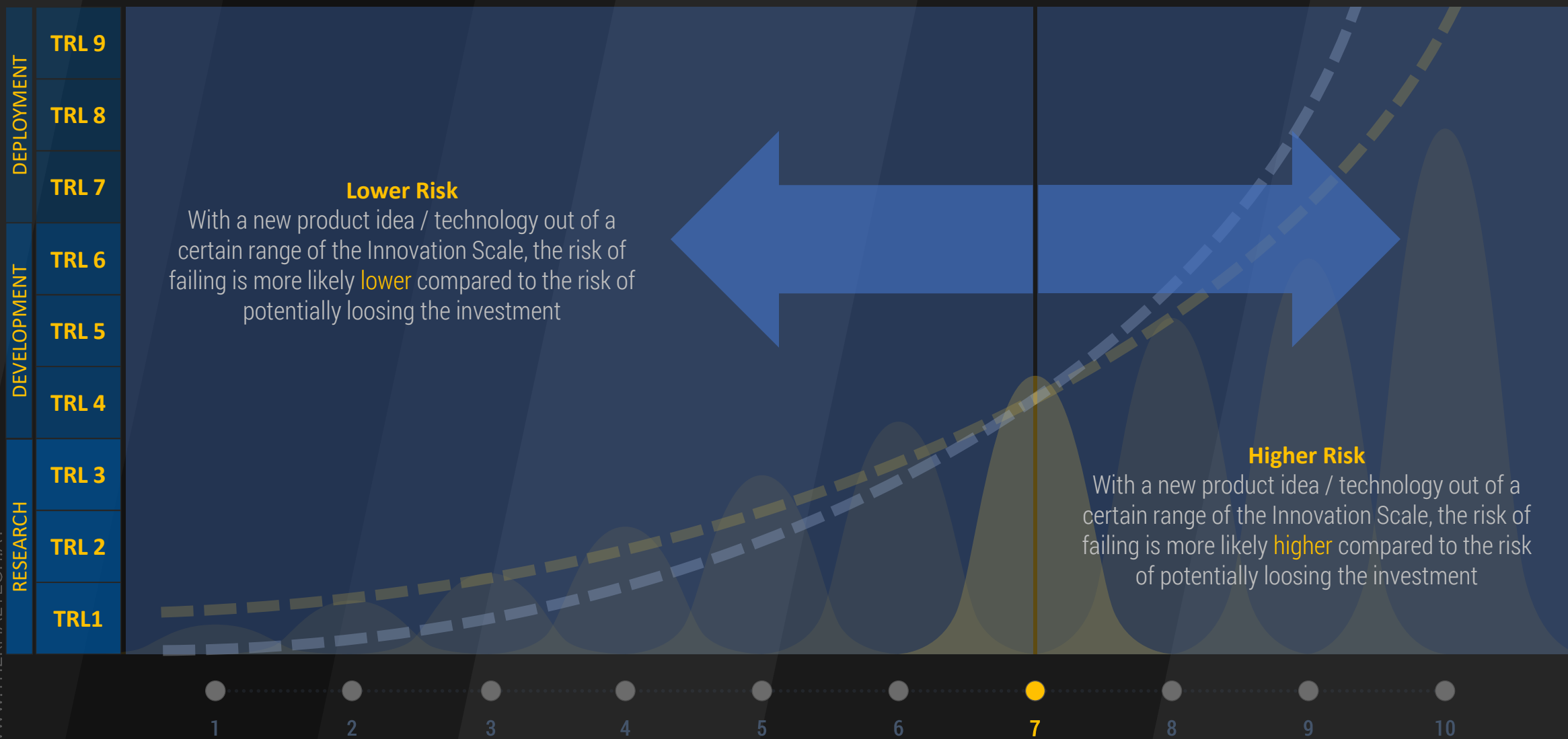
Innovation vs Printed Electronics

Innovation vs TRL vs Investment vs Risk (Risk of failing until reaching TRL9)



Innovation vs Printed Electronics

Innovation vs TRL vs Investment vs Risk



■ Innovation vs Printed Electronics

The Challenges in Automotive Industry

- Purchasing vs Innovation vs Investment vs Risk
- Critical: having a lot of solutions, which all search for a problem! (= Solution oriented thinking)
- New Products / Innovations **MUST** solve a dedicated problem of the industry! (= Problem oriented thinking)
- Problem oriented vs. solution oriented thinking
- 70%– 90% of the entire budget needed for the product development process will be consumed by
 - Industrialization
 - Validation, Qualification and Quality
- Critical question: who exactly in the supply chain is going to pay for the development?
- Requirements are often not in alignment with new technologies



■ Use Case Thermal Comfort Optimization of EVs

Optimization Comfort and Energy Efficiency through heat radiation emitting surfaces in the vehicle cabin

- Thermal comfort is a **crucial aspect of the human-machine interface** that can significantly impact overall product satisfaction.
- To ensure optimal thermal comfort, state-of-the-art methodology is required, just like any other product function.
- The human body **interprets heat flux, not temperature**, as a warm or cold sensation, making it a critical consideration for thermal comfort engineering.
- As a thermal power plant, the human body always needs to lose a certain amount of energy to maintain comfort, and any deviation from this can result in feelings of cold or warmth.

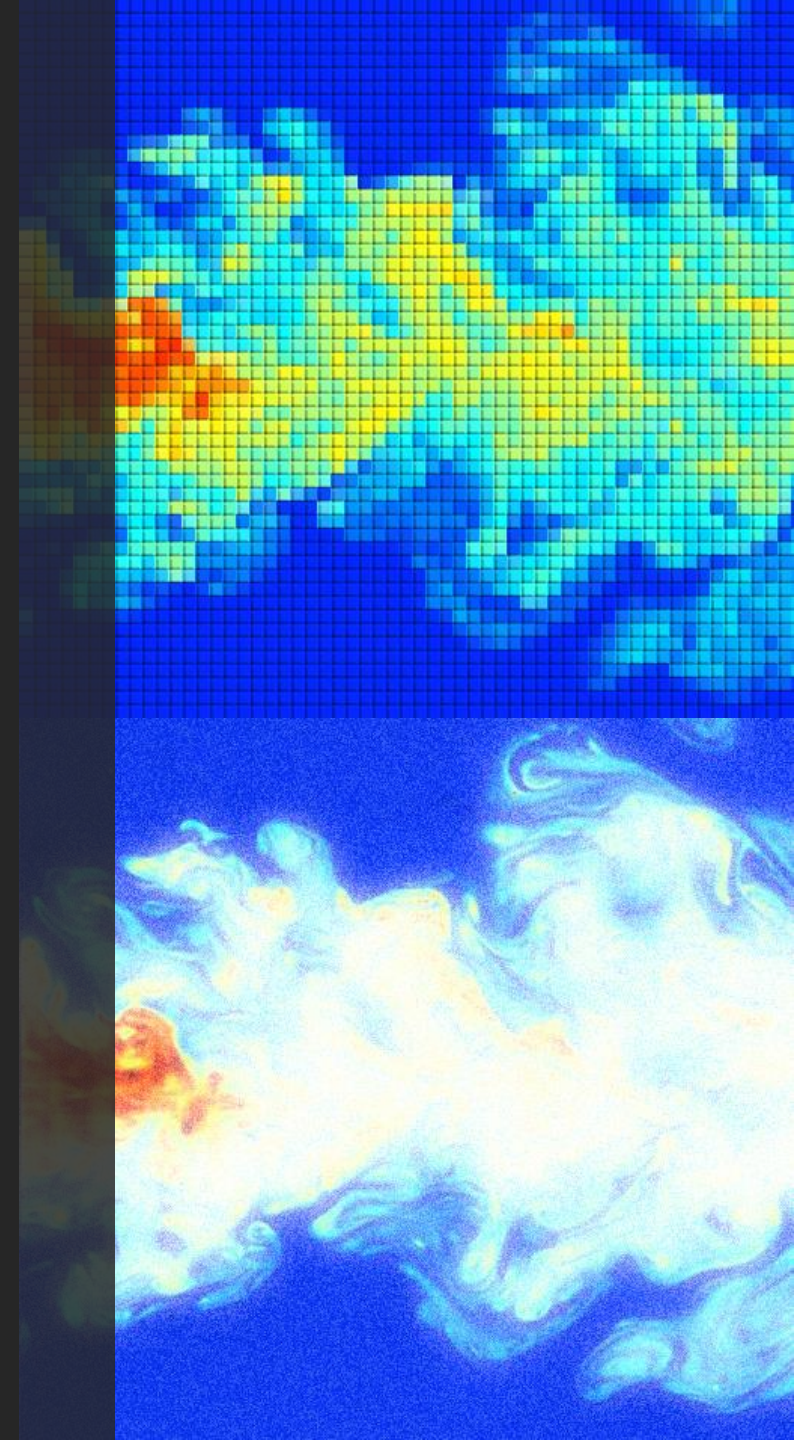




■ Use Case Thermal Comfort Optimization of EVs

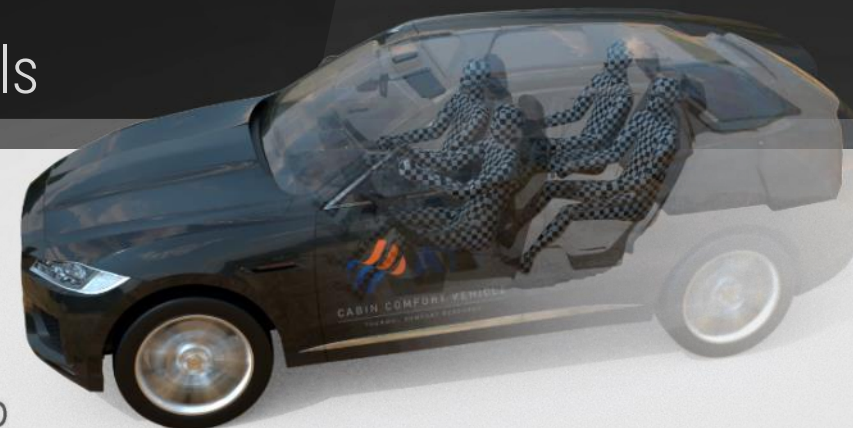
In the future, surface heating systems will not simply be an optional feature.

- With the growing adoption of electric vehicles, the importance of **efficient thermal management systems** in the cabin cannot be overstated, and heat radiation surfaces is be a viable solution.
- The **integration of heat radiation surfaces** leads to significant energy savings (up to 25%) and improves the overall range of electric vehicles.
- While traditional heating systems rely on convection, which is less efficient, **decentralized heating systems** that rely on heat radiation surfaces provide a more precise and efficient way to manage the thermal comfort.
- Integrating heat radiation surfaces will require a **paradigm shift** in the design and engineering of thermal management systems in vehicles, but the potential benefits are worth exploring.



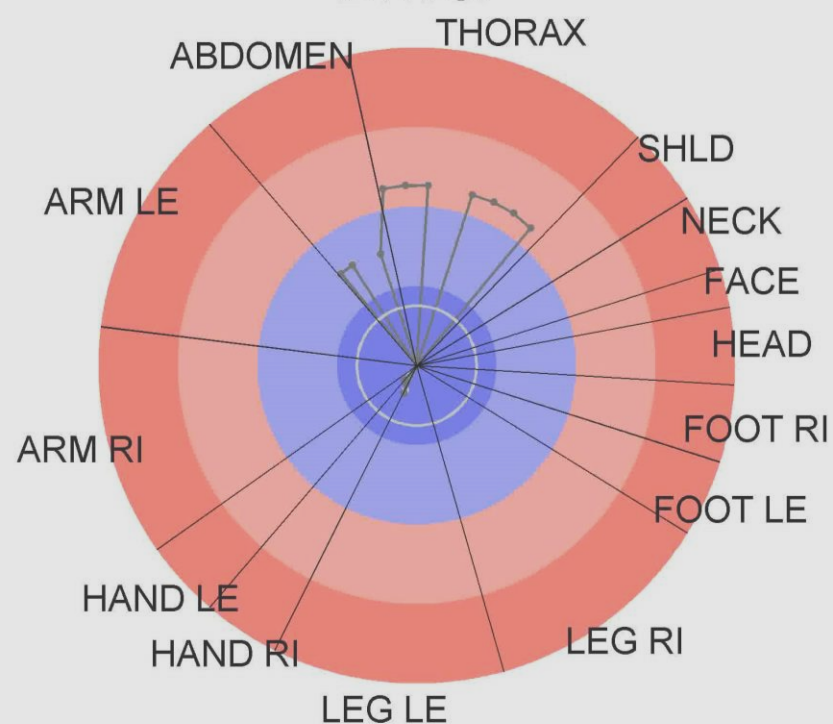
Use Case Thermal Comfort Optimization of EVs

Direct comparison with and without heat radiating surface panels

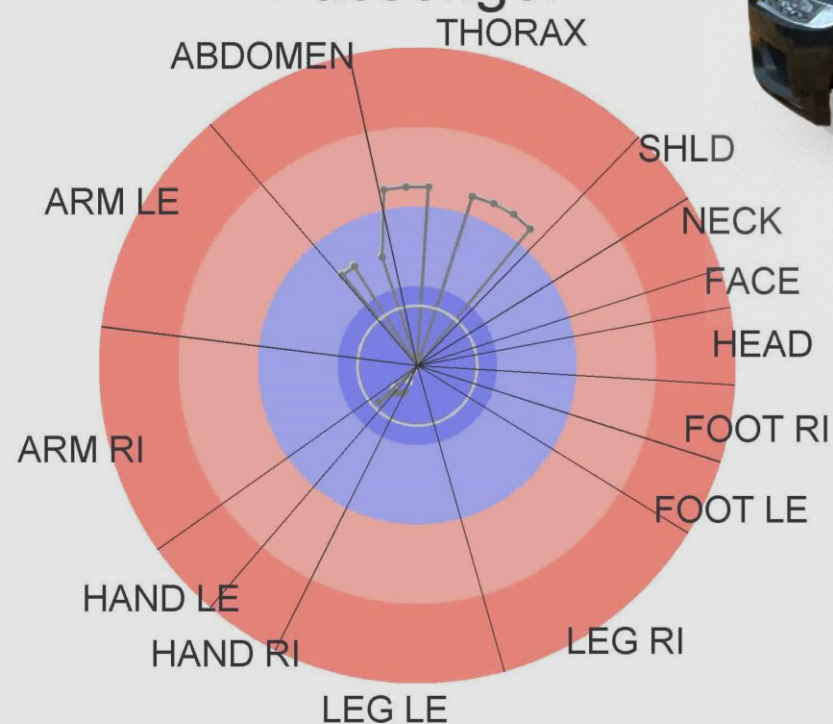


$t = 0 \text{ min}$

Driver



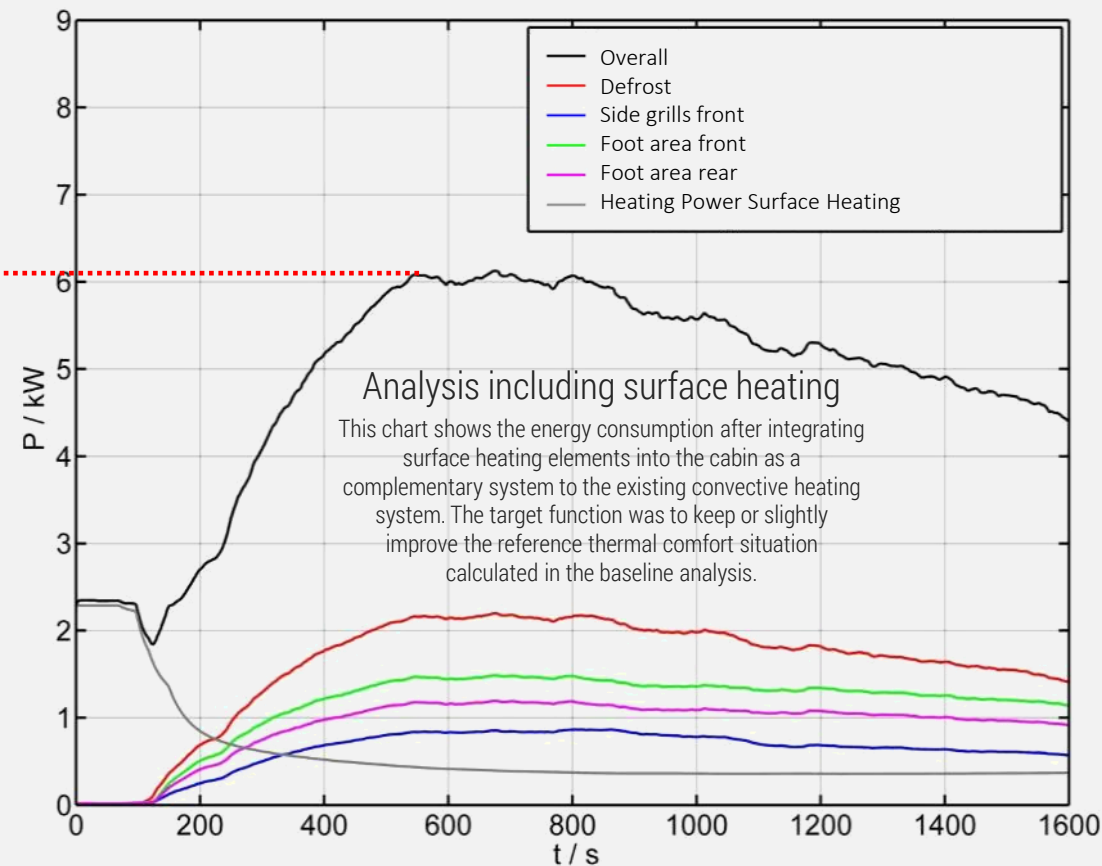
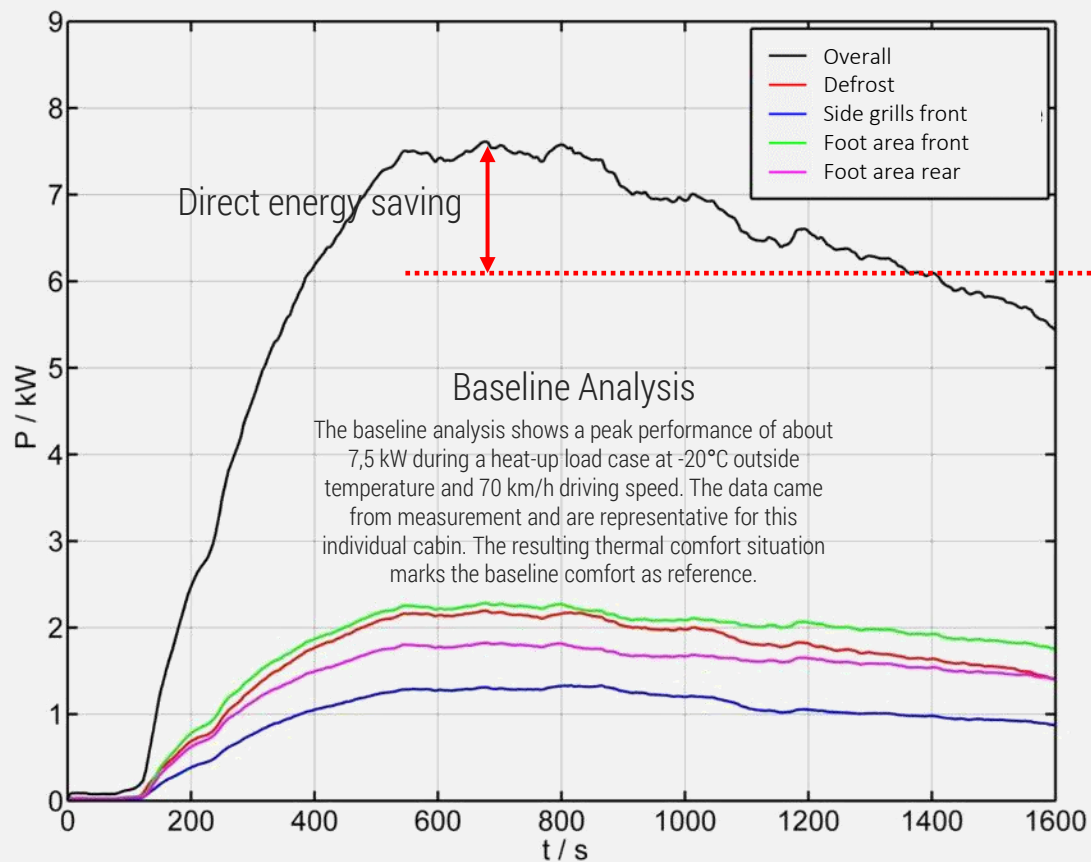
Passenger



Light grey: Baseline
Dark grey: Surface Heating

Use Case Thermal Comfort Optimization of EVs

What **benefits** can be expected from a well integrated surface heating system?



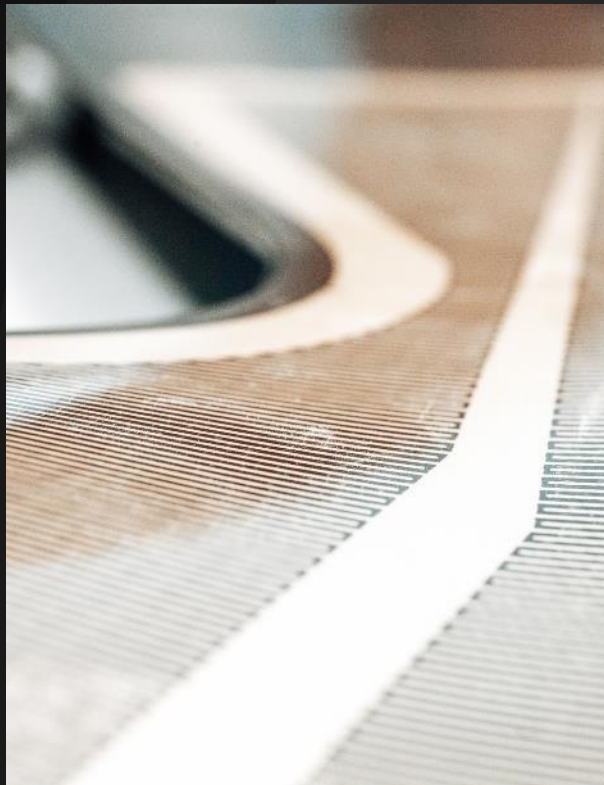
Use Case Thermal Comfort Optimization of EVs

Printed Heaters have advantages compared to wire-based heaters!



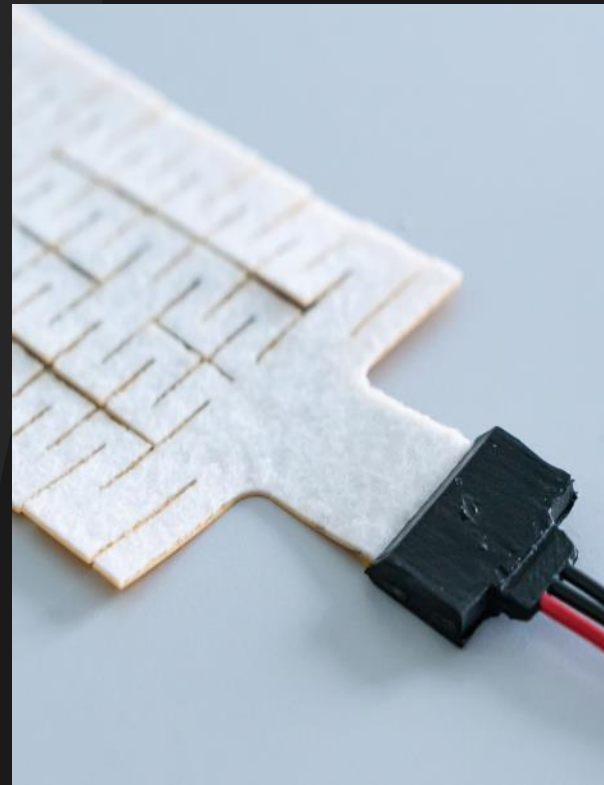
Integration Method 1

Example heatable sun visor. The heating element will be attached on a specially prepared foam carrier.



Integration Method 2

Example dorr trim panel. The heating elements is placed inside the tooling before being pressure molded. With this method, the heating element gets completely integrated into the plastic part.



Integration Method 3

The heating element gets placed between 2 specially designed haptic foams, which are perforated in a certain way. The heating element goes below the leather or fabric and can withstand mechanical and chemical stress. Due to the perforation and the used materials is absolutely noise free.



Integration Method 4

The heating element is placed either on the A or B side of a plastic part. The heater features a dedicated double side adhesive, which is also suitable for HDPE plastic parts.



■ Use Case HV Battery Thermal Management

Printed Heaters with PTC Effect

Requirements

- High power density up to 350 kW/m^2
- Lightweight
- Fast heat-up
- Least possible thermal resistance
- Driven by HV or LV
- Easy to integrate
- Combinable with other functions
 - NTC Temperature Sensor
 - Leakage
 - Impact
 - Hot Spot Detection





■ Use Case ADAS Camera Cover Heaters

Printed Silver and PTC Heaters

Requirements

- Transparent in dedicated wave lengths
- Back-injection moldable
- Method of connection patented by ATT
- Fast heat-up
- Highly efficient
- PWM controllable
- Combinable with printed sensors
 - NTC Temperature Sensor
 - Ice
 - Snow
 - Mist



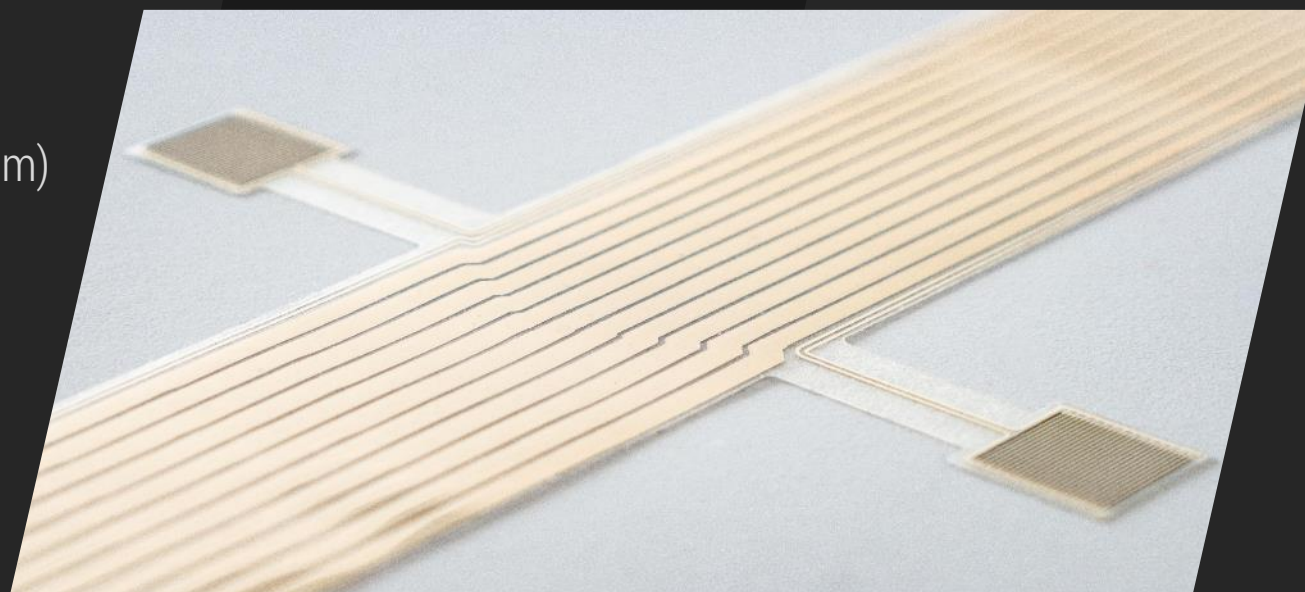
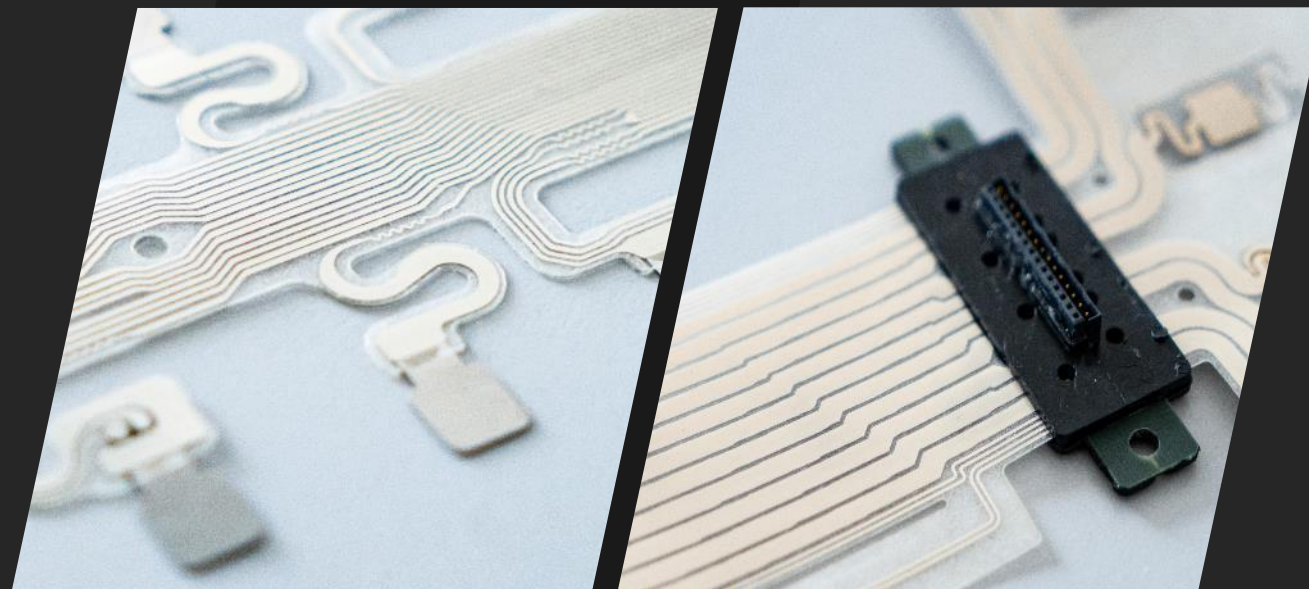


■ Use Case **Integrated FPCs**

Flexible Printed Circuits (FPC)

Requirements

- Alternative to etched flexible circuits
- Alternative to cables
- Much less restricted in size
- Cheaper than etched parts
- Signal transport & Power supply
- Combinable with other printed functions
 - NTC Temperature Sensor (very thin <20 μm)
 - Hot Spot Detection



■ Challenges and Opportunities

Summary

- Printed electronics offer promising solutions for thermal management in various applications, including automotive industry.
- In the automotive sector, printed heaters can optimize thermal comfort and improve energy efficiency, while printed sensors and circuits can enhance safety and performance.
- However, there are still challenges to overcome, such as durability, reliability, and scalability of printed electronics.
- Despite the challenges, the opportunities of printed electronics are significant, and their potential impact is far-reaching.

"The only way to discover the limits of the possible is to go beyond them into the impossible."

Arthur C. Clarke.



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