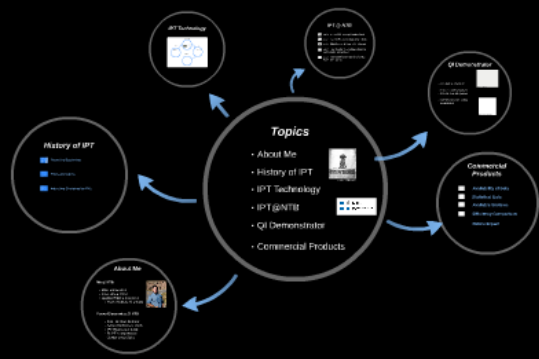
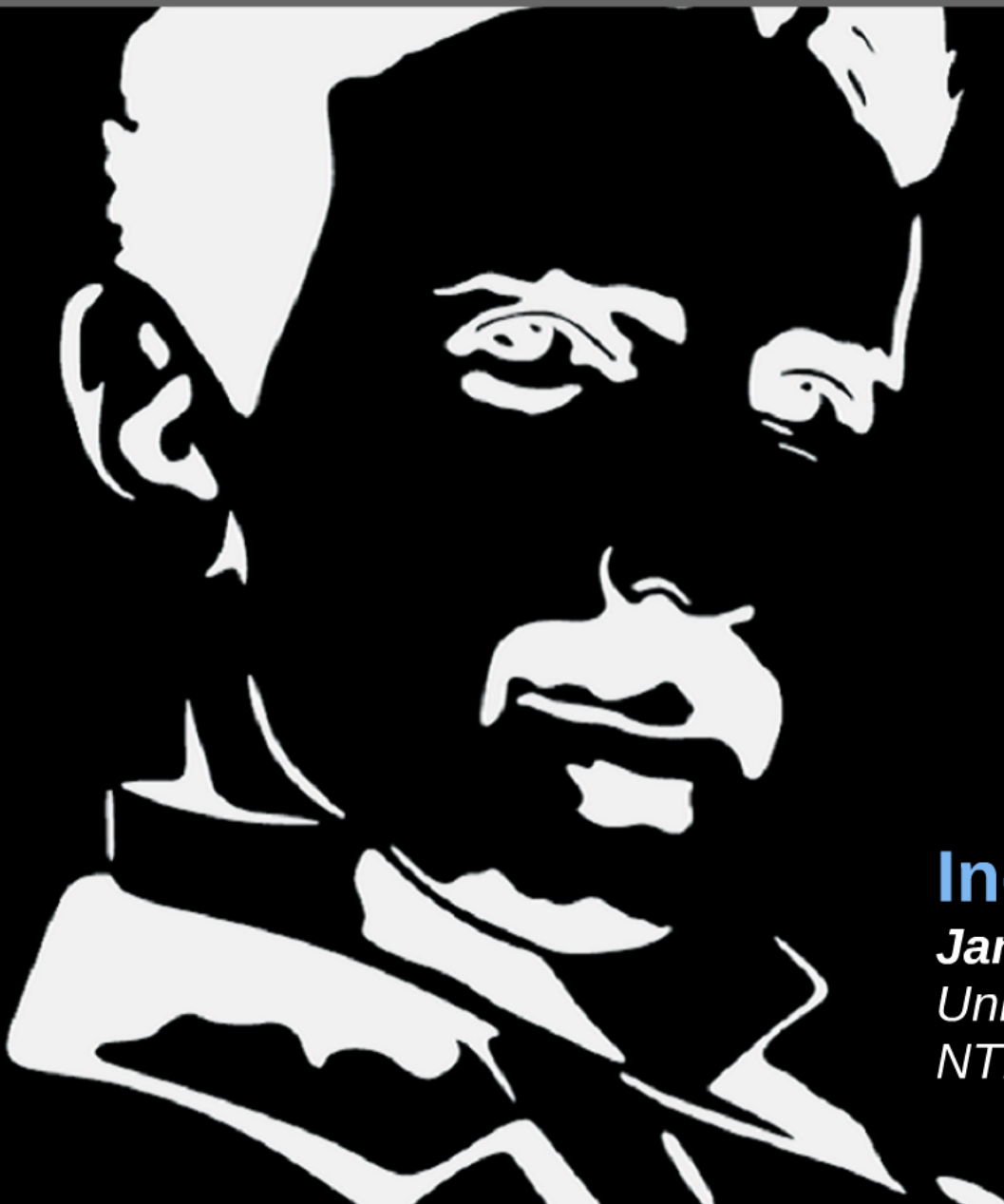


# Inductive EVSE Technology

*Janosch Marquart*  
University of Applied Sciences  
NTB Buchs



**Inductive EVSE Technology**  
*Janosch Marquart*  
*University of Applied Sciences*  
*NTB Buchs*

# Topics

- About Me
- History of IPT
- IPT Technology
- IPT@NTB
- QI Demonstrator
- Commercial Products



Source: Wikipedia



# About Me

## Me @ NTB

- BSc. since 2011
- MSc. since 2014
- Applied R&D since 2011
  - From Watts to Kilowatts



## Power Electronics @ NTB

- Prof. Dr. Kurt Schenk
- Active R&D since 2010
- IPT R&D since 2012
- ECPE Competence Center since 2016

# *History of IPT*



**From the Beginning**



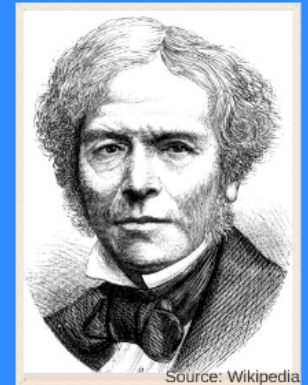
**Pro's and Con's**



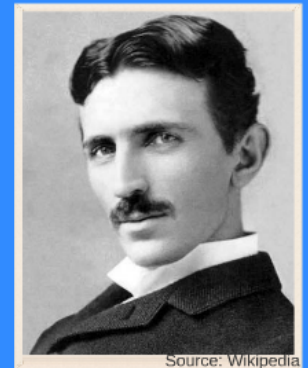
**Inductive Charging for EVs**



- **1831** - M. Faraday discovers and proves electromagnetic induction.
- **1887** - N. Tesla starts research in the field of AC-systems (synchronous machines) and high frequency AC systems.
- **~1995** - First electric toothbrushes are charged without cables.
- **1999** - Conductix-Wampfler demonstrates inductive energy transfer for elevators at the world exhibition in Hannover.
- **2002** - Conductix-Wampfler starts inductive charging for first electric busses in Genau and Turin.
- **2007** - M. Soljagic (WiTricity) is capable of transferring 60 W for a lightbulb over the distance of 2 m.
- **2008** - Foundation of the Wireless Power Consortium, which later introduces the well known Qi standard.
- **2010** - First smartphones can be charged wireless.
- **2015** - Commercial 3.5 kW ICS



Source: Wikipedia  
Michael Faraday



Source: Wikipedia  
Nikola Tesla



Source: <http://news.mit.edu/2007/wireless-0607>

M. Soljagic and his Team



## Pro's

- Increased reliability and lifetime of systems.
- New degree of freedom e.g. for design.
- Increased comfort.
- Increased safety.

## Con's

- Magnetic field in the air
- Alignment for efficient charging
- LOD and FOD can interrupt charging.



## Static Charging

- The Vehicle is not moving for a long to medium period of time (e.g. > 5 minutes).
- Driver does not intend to use the vehicle soon.
- **Possible scenarios:** Parking at home or at the office

## Stationary Charging

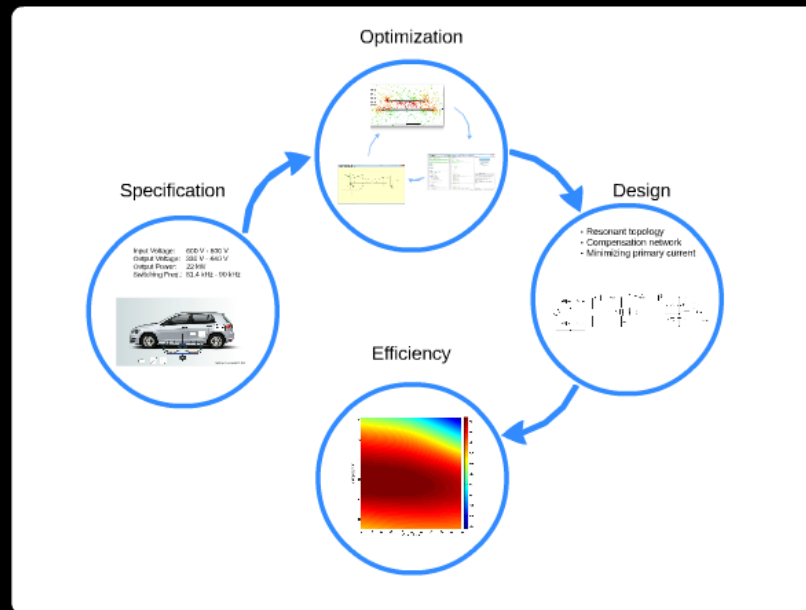
- The Vehicle is not moving for a short period of time (e.g. < 5 minutes).
- Driver remains in the vehicle.
- **Possible scenarios:** Traffic lights, bus stops or delivery trucks.

## Dynamic Charging

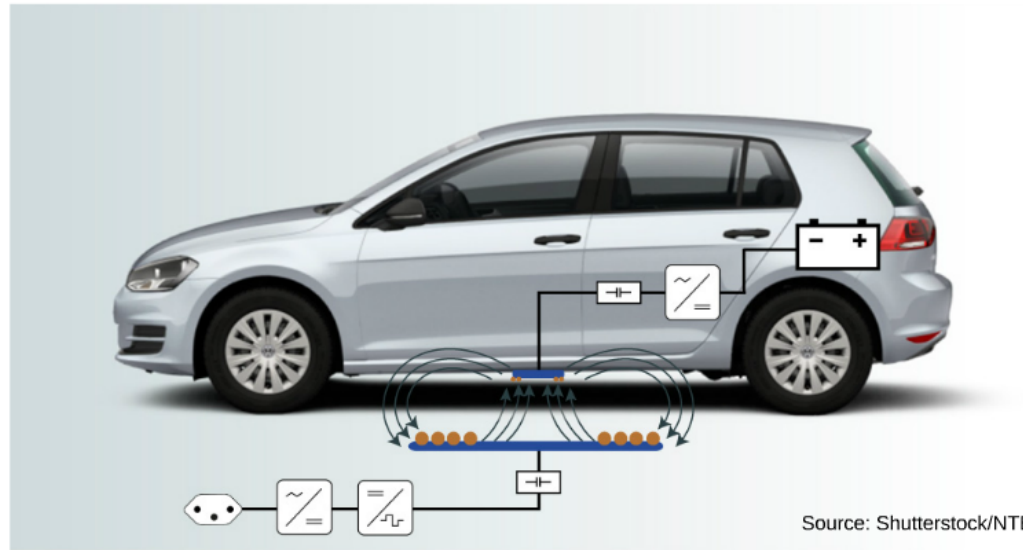
- The Vehicle is moving while being charged.
- Driver remains in the vehicle.
- **Possible scenarios:** Traveling on highways or on city streets.



# ***IPT Technology***



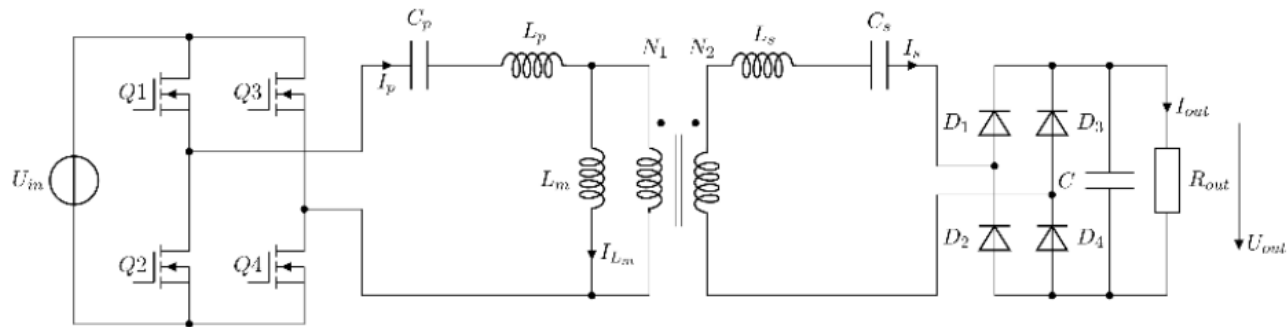
Input Voltage: 600 V - 800 V  
Output Voltage: 330 V - 440 V  
Output Power: 22 kW  
Switching Freq.: 81.4 kHz - 90 kHz

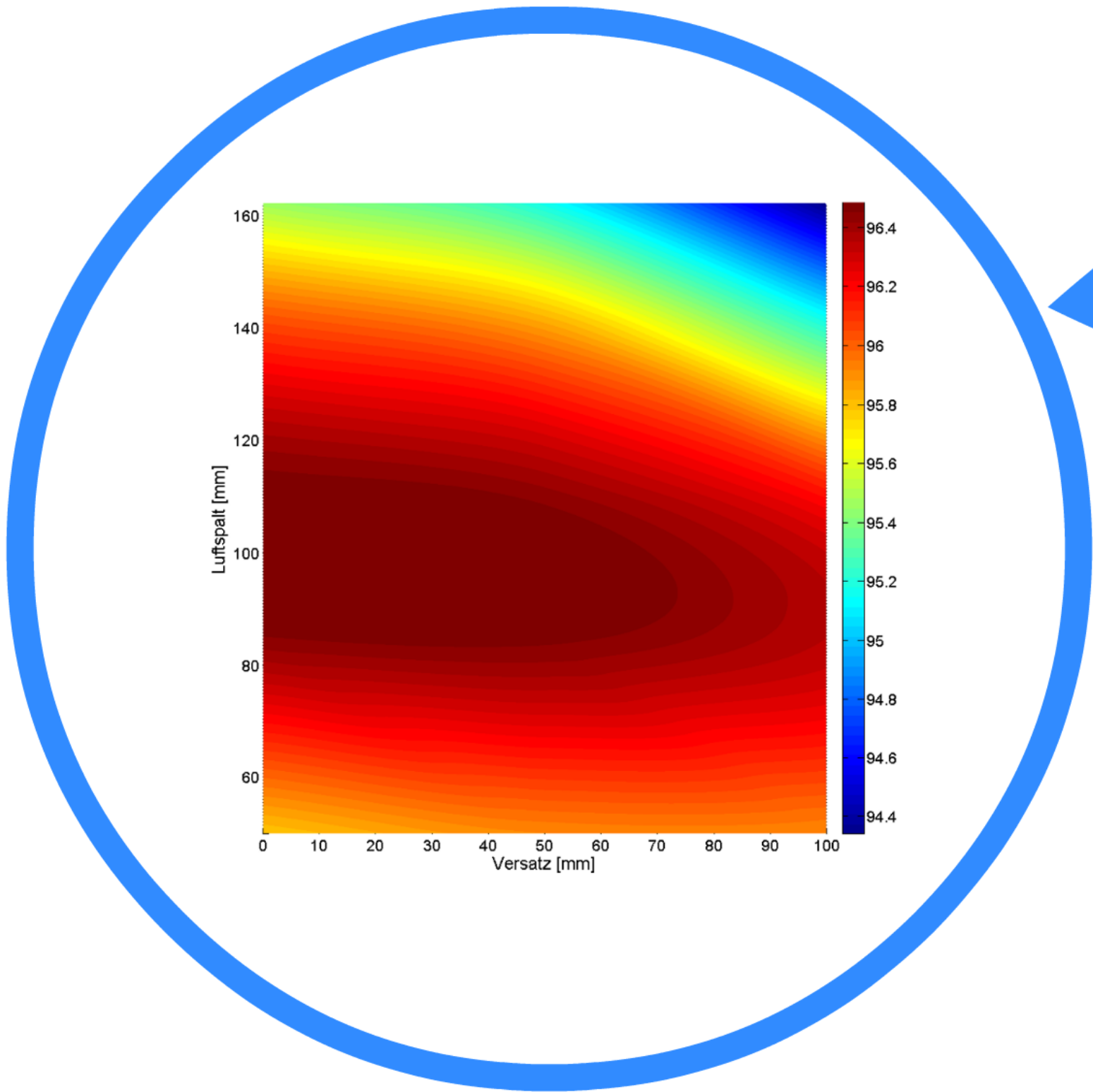


Source: Shutterstock/NTB

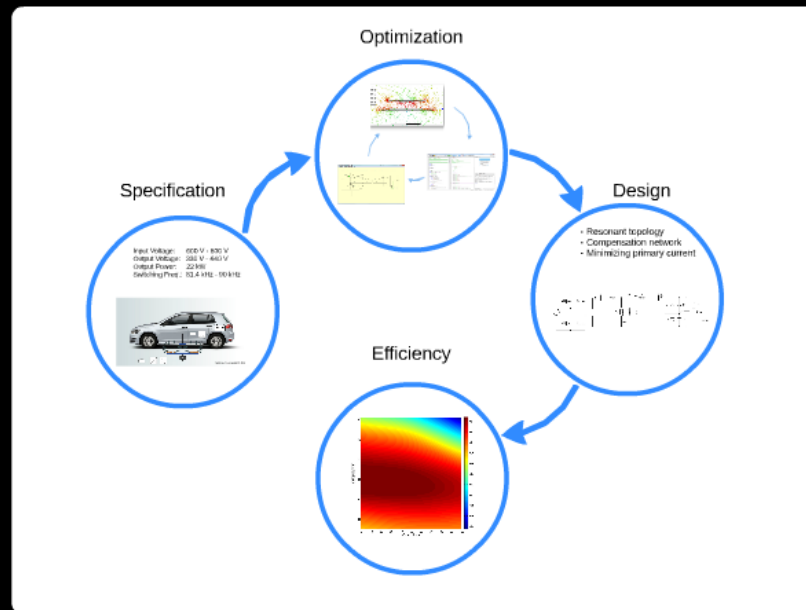


- Resonant topology
- Compensation network
- Minimizing primary current










# ***IPT Technology***

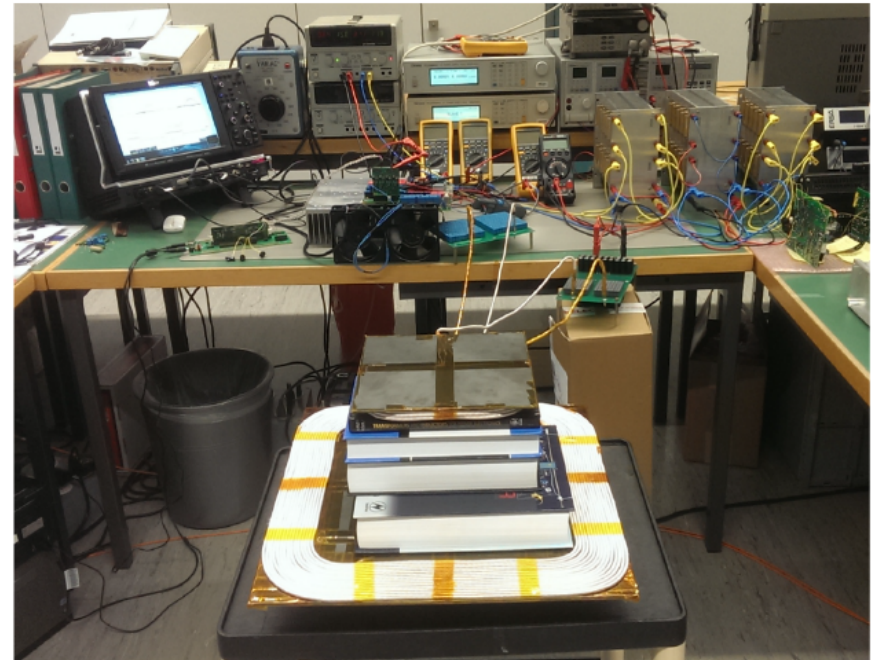
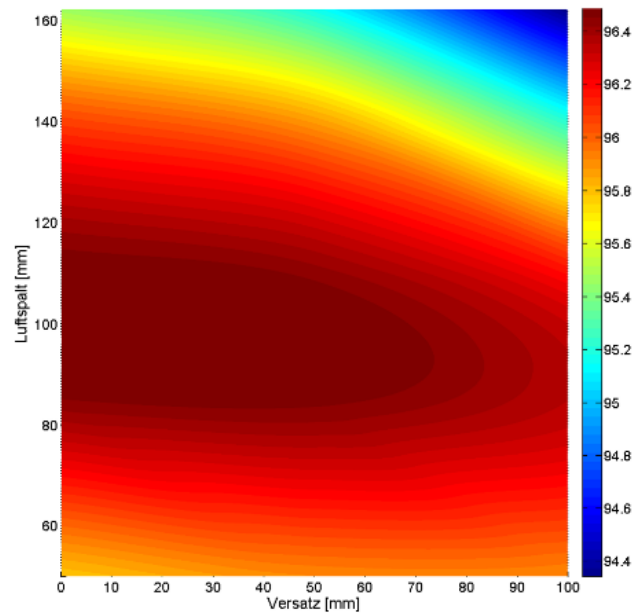


# ***IPT @ NTB***

-  2012: 3.5kW IPT during Master thesis
-  2014: 7.2kW IPT during Bachelor thesis
-  2015: 11kW/22kW IPT as a CTI Project
-  2017: Task leader "innovative charging technology" for SCCER
-  2017: Representing Switzerland at IEA HEV TCP Task 26



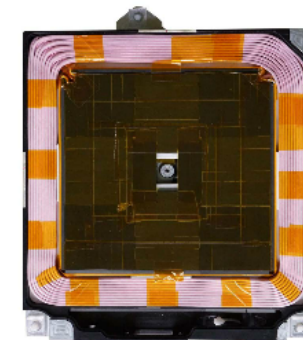
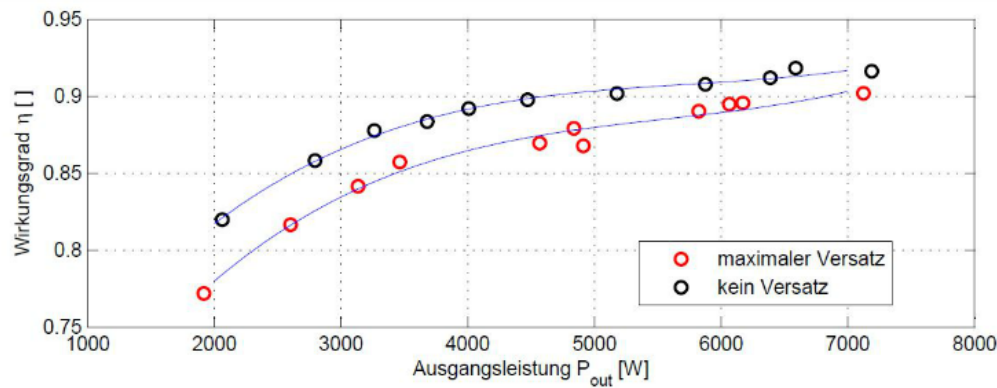
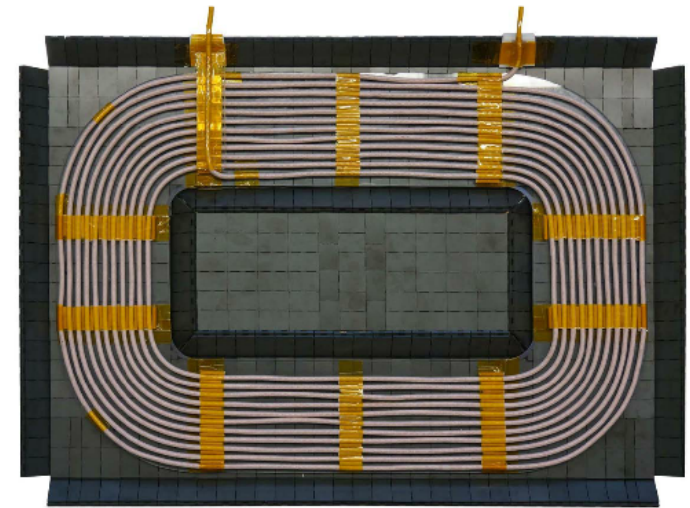
- Power Level: 3.5 kW
- Output Voltage: 400 V
- Switching Freq.: 96 kHz
  
- CPM: 250 mm x 250 mm
- Misalignment: 60 mm (x-Axis)
- Misalignment: 90 mm (y-Axis)
- Airgap: 50 mm - 160 mm



Early Lab Demo



- Power Level: 7.2 kW
- Output Voltage: 200 V - 440 V
- Switching Freq.: 85 kHz  $\pm$  5 kHz
  
- CPM: 250 mm x 250 mm
- Misalignment: 75 mm (x-Axis)
- Misalignment: 150 mm (y-Axis)
- Airgap: 100 mm - 200 mm








Early Prototype



**Early Testsetup of 22 kW System  
Efficiency up to 96 %**

# ***IPT @ NTB***

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-  2015: 11kW/22kW IPT as a CTI Project
-  2017: Task leader "innovative charging technology" for SCCER
-  2017: Representing Switzerland at IEA HEV TCP Task 26



# Qi Demonstrator

- 110 kHz to 250 kHz
- 5 W / 15 W low power
- 120 W medium power
- Communication using modulation



# ***Commercial Products***



**Availability of Data**



**Statistical Data**

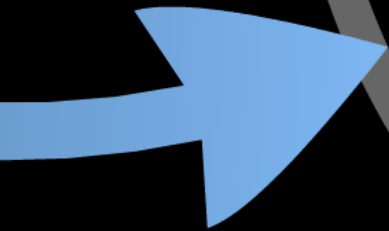


**Available Systems**



**Efficiency Comparison**

**Future Impact**



## Official Sources

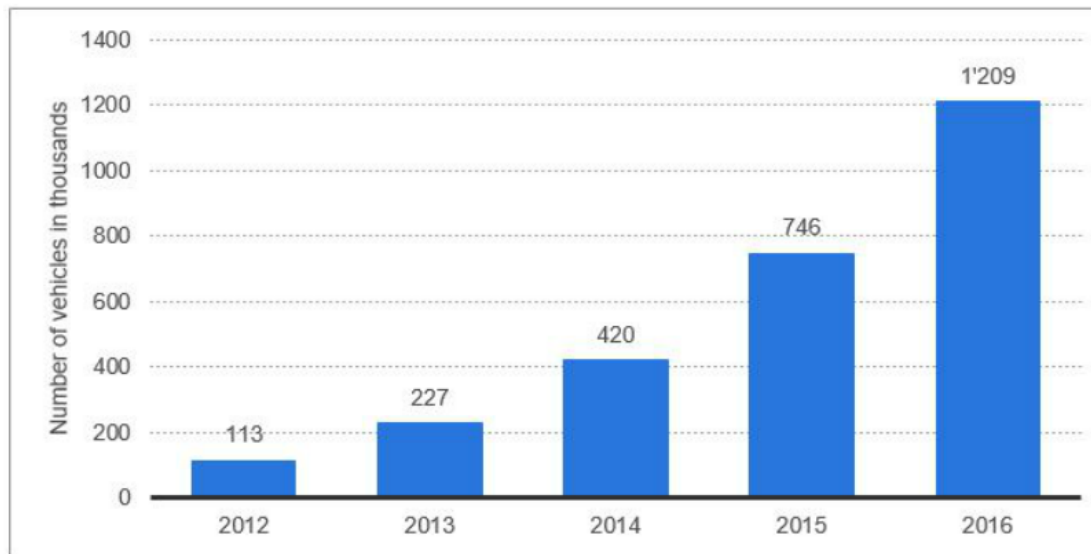
Almost no official sources

## System Comparison

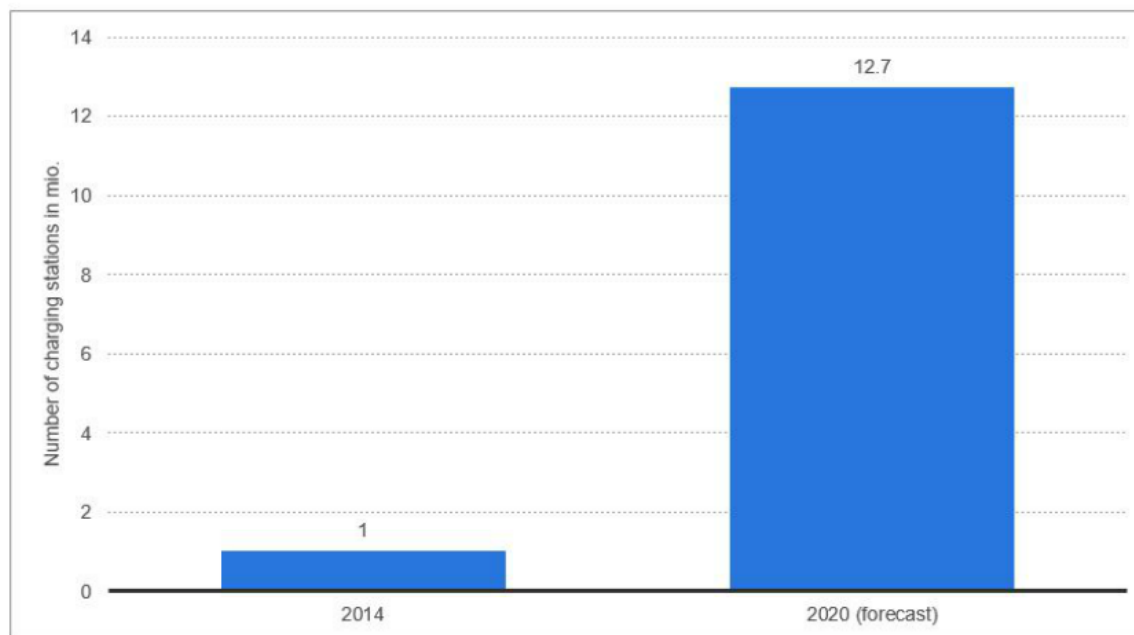
Difficult to compare as the standardization process is not yet finished.

## Competition

Heavy competition, everyone wants to get a piece of the cake!



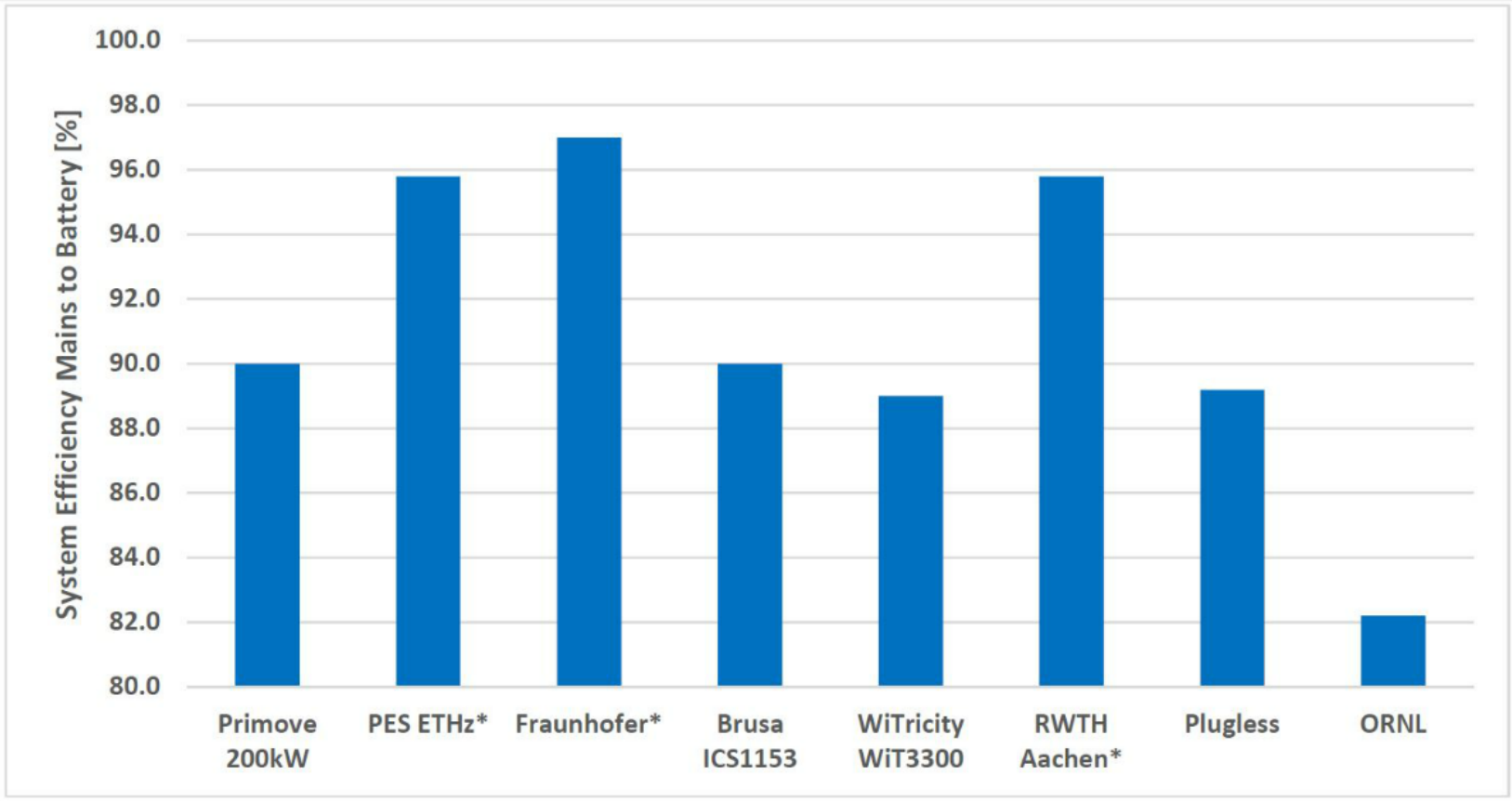
Source: <http://www.statista.com/statistics/270603/worldwide-number-of-hybrid-and-electric-vehicles-since-2009/>



Source : <http://de.statista.com/statistik/daten/studie/431317/umfrage/ladestationen-fuer-elektroautos-weltweit>

PluglessPower	<a href="https://www.pluglesspower.com/">https://www.pluglesspower.com/</a>
Qualcom Halo	<a href="https://www.qualcomm.com/products/halo">https://www.qualcomm.com/products/halo</a>
Conductix Wampfler	<a href="http://www.conductix.ch">http://www.conductix.ch</a>
Kaist (Korea)	<a href="http://www.kaist.edu">http://www.kaist.edu</a>
Bombardier PRIMOVE	<a href="http://primove.bombardier.com">http://primove.bombardier.com</a>
Momentum Dynamics	<a href="http://www.momentumdynamics.com">http://www.momentumdynamics.com</a>
WiTricity	<a href="http://witricity.com/">http://witricity.com/</a>
Eaton HEVO	<a href="https://www.hevopower.com/">https://www.hevopower.com/</a>
IPT Technology GmbH	<a href="http://www.ipt-technology.com">http://www.ipt-technology.com</a>
ORNL WPT (DOE Oak Ridge National Lab)	Licenses the technology to the private sector.





# ***Commercial Products***



**Availability of Data**



**Statistical Data**

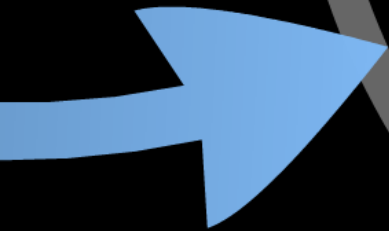


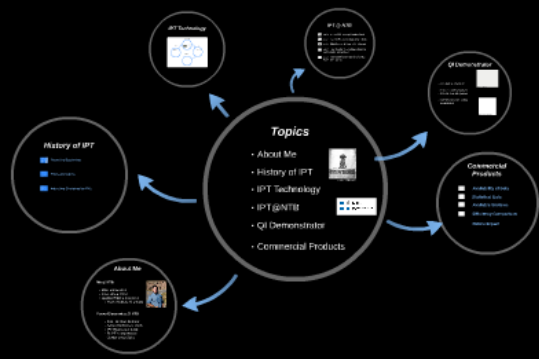
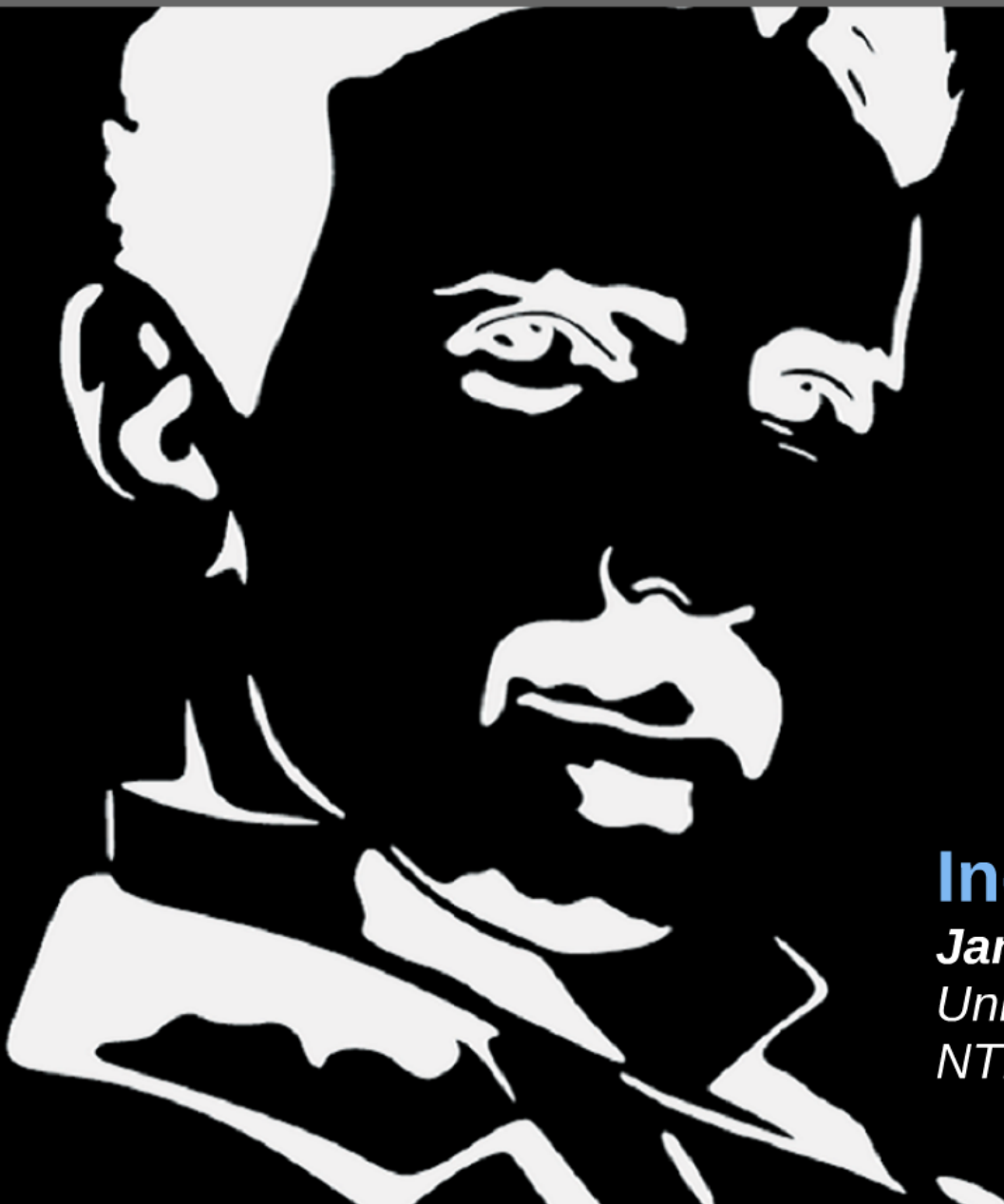
**Available Systems**



**Efficiency Comparison**

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