
H2 MOBILITY
FUELLING HYDROGEN

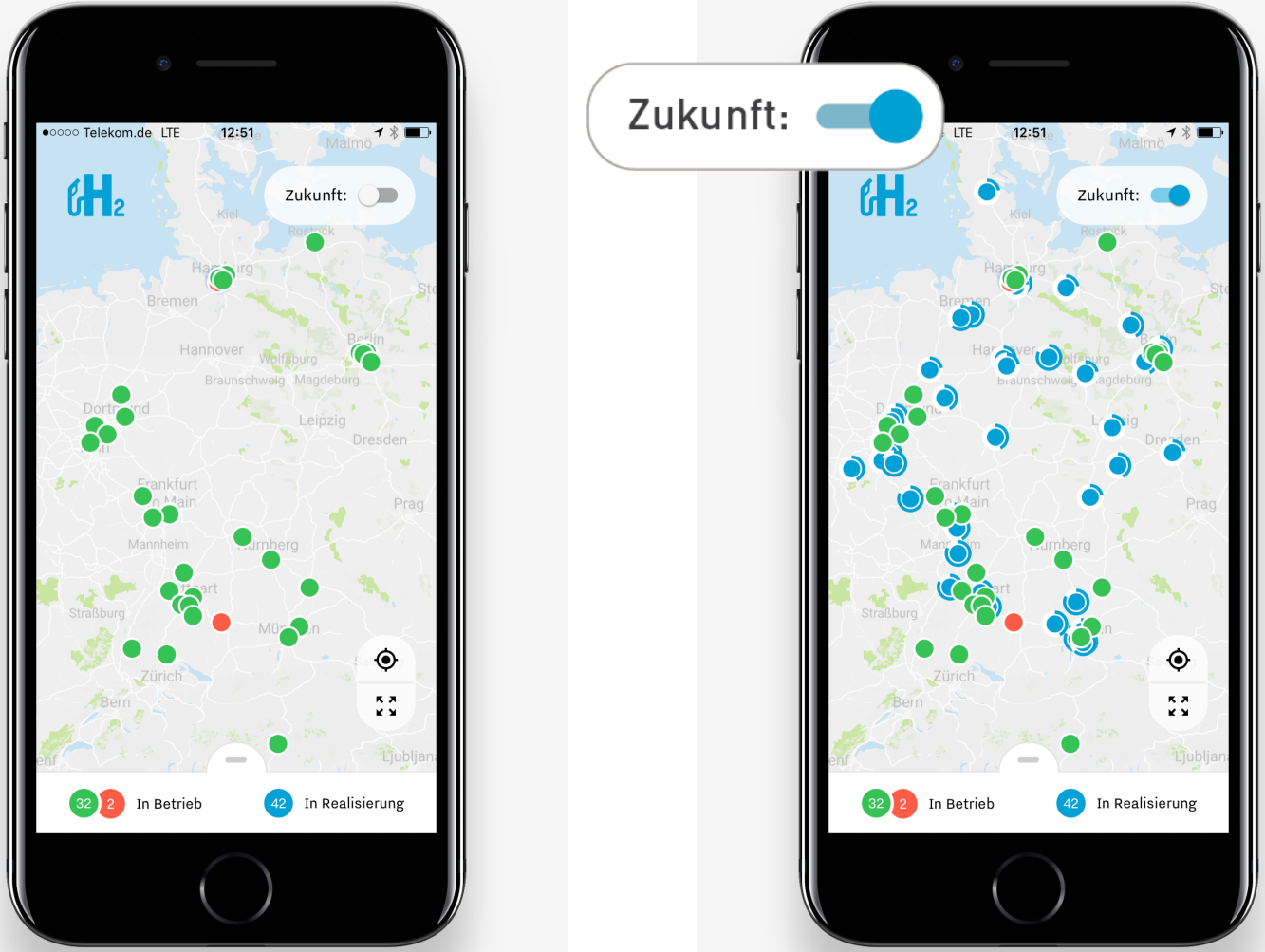
Welcome, HSSE, Intro NW Delivery & Operations
Wer ist H2 MOBILITY?
Was ist der Platz von H2 in der Energiewende?
Was sind die Kosten der Infrastruktur?
Vergleich FCEV und BEV
Diskussion

H2 MOBILITY is a JV by 6 industry leaders

AND THE MOST AMBITIOUS H2 INFRASTRUCTURE PROJECT WORLDWIDE

H2 MOBILITY is a JV by 6 industry leaders

supported by 6 OEMS and german government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THE FUTURE OF OUR ENERGY SYSTEM WILL BE SUNNY AND WINDY!

Working assumptions about the energy of the future

- The electrification of the energy system in Germany and the growth in renewable energy is an irreversible trend for decades to come.
- It will lead to at least 80% “green” electricity.
- The renewable electricity generation will be dominated by wind and solar.

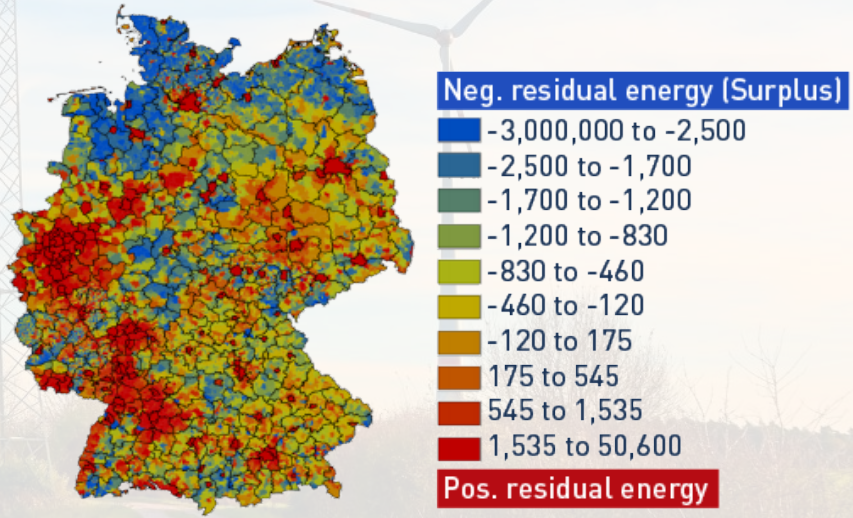
The electricity supply will become increasingly volatile!

AT 80% RENEWABLE ELECTRICITY THERE WILL BE A SIGNIFICANT RESIDUAL ENERGY OF AROUND 270 TWH …

Electricity surplus set to increase

- High residual energy generation thanks mainly to onshore (N-E) and offshore (N-W) wind
- At 80% green electricity, annual surplus can reach 270 TWh
- Note: 90 TWh will be enough to power half of the fleet in Germany with H2 (or 20 million FCEV)

Residual energy MWh/km2



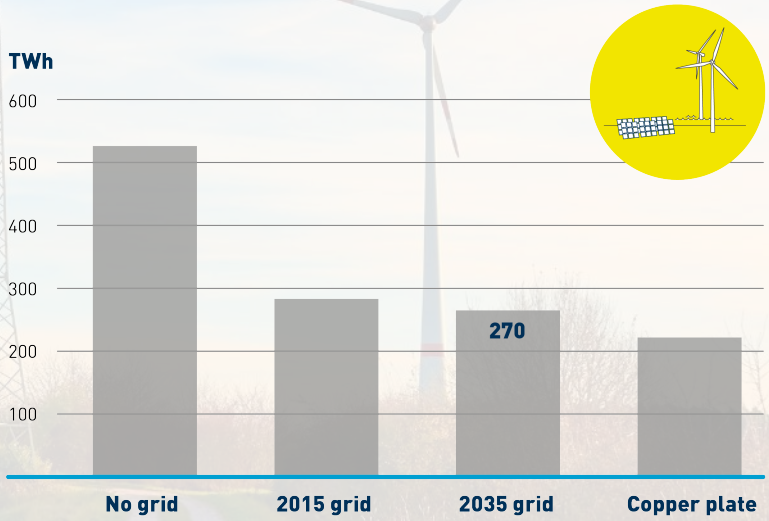
Source: Robinius, 2015

... AND EVEN THE PERFECT GRID WON'T HELP

The grid will not solve the problem!

- Even a perfect grid will reduce surplus by only 50 TWh – from 270 to 220 TWh
- The wind doesn't (always) blow and the sun doesn't (always) shine when demand requires it

Curtailment of renewable energy



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WHAT IS THE INVESTMENT REQUIRED TO FUEL OR CHARGE 20 MILLION EV'S?

We want to provide a solid foundation on which to discuss the cost of infrastructure!

- Is the infrastructure for FCEVs expensive?
- What about BEVs?

Available literature does not give us the answers we need!

- Comprehensive analysis of 79 existing studies with focus on Germany
- Assumptions behind the studies are mostly not provided or transparent
- General tendency: H2 infrastructure is seen to be expensive, no results for higher numbers of BEV so far

FIRST DOMINATED BY HOME CHARGING, WITH INCREASING NUMBERS OF CARS MOST INVESTMENT GOES TO GRID EXPANSION AND FAST CHARGERS

	1,800 km x6,100*	28,000 km x55,000	183,000 km x187,000
3.7 kW x100,000	x2.8 mill	x6,5 mill	x11 mill 22 kW
150 kW x6,000	x81,000	x175,000	x245,000 350 kW

100,000 | 3 mill. | 10 mill. | 20 mill.

Ramp-up | Mass market

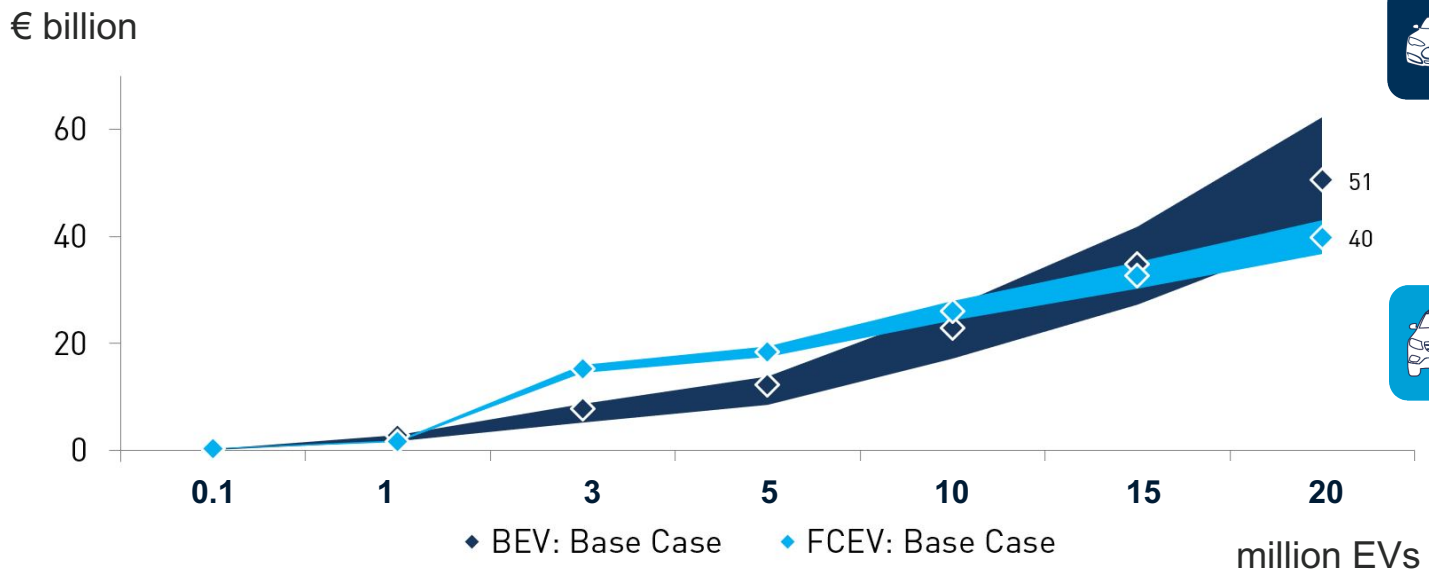
*Transformer; the number in km is the necessary length of cable for expanding the distribution grid

FIRST DOMINATED BY REFUELLING INFRASTRACTURE, AT 3 MIO FCEV'S AND BEYOND THE INVESTMENT IS DRIVEN BY PRODUCTION AND STORAGE

	2 TWh* 3 GW	5 TWh 10 GW	10 TWh 19 GW
x42	x730	x1,500	x3,000
	12,000 km	12,000 km	12,000 km
x400	x1,500	x3,800	x7,000
100,000	3 mill.	10 mill.	20 mill.
Ramp-up	Mass market		

*in TWh: the required storage capacity in GW: the required size of electrolyzers

IN THE LONG RUN THE INVESTMENT IN CHARGING INFRASTRUCTURE WILL BE 11 BILLION € HIGHER



Sensitivity:

Top // larger batteries with 100 kWh dominate in the long run (base case +100 kWh)
Bottom // no fast charging at 350 kW in cities

Top // base case +20% investment in stations
Bottom // base case -20% investment in stations

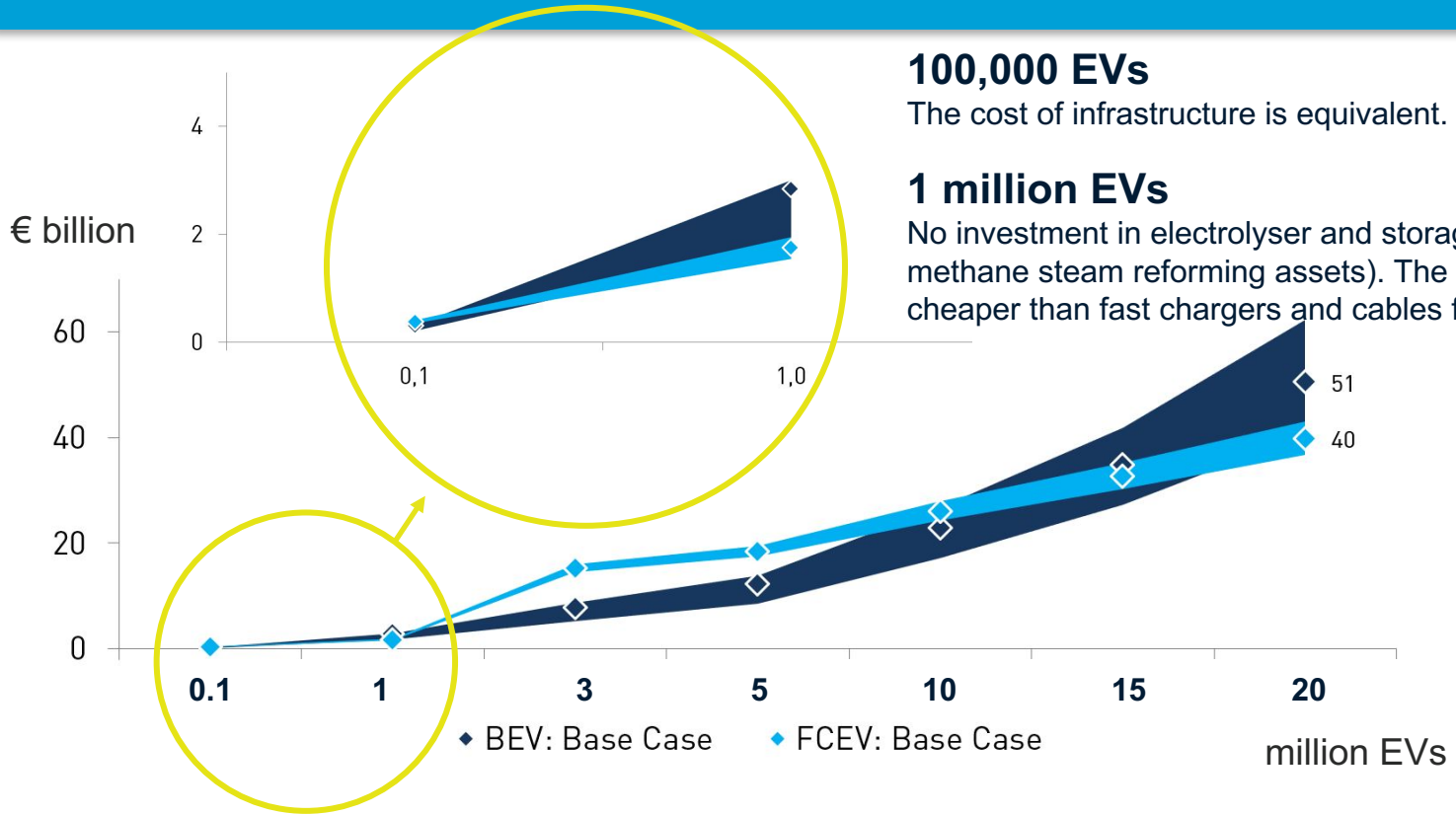
THE COST FOR REFUELLING STATIONS IS LOWER THAN FOR CHARGERS – ALREADY ABOVE 100.000 VEHICLES

100,000 EVs

The cost of infrastructure is equivalent.

1 million EVs

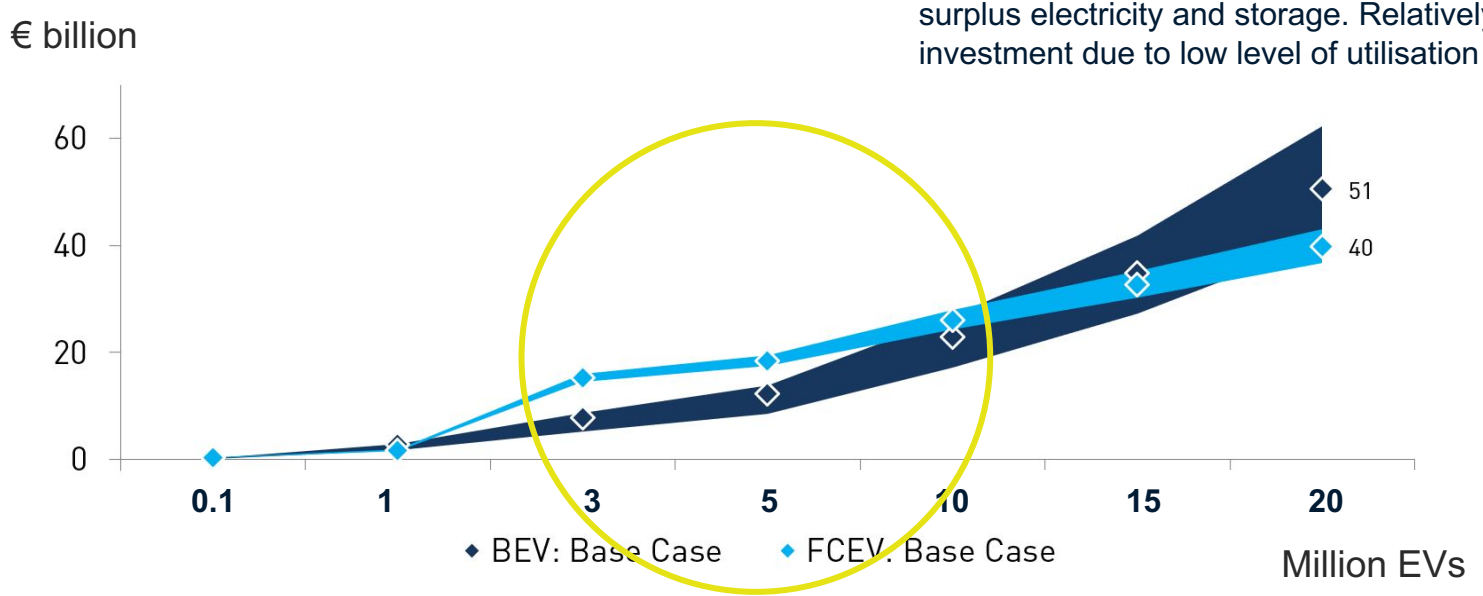
No investment in electrolyser and storage yet (using existing methane steam reforming assets). The refuelling stations are cheaper than fast chargers and cables for 1 mill BEVs.



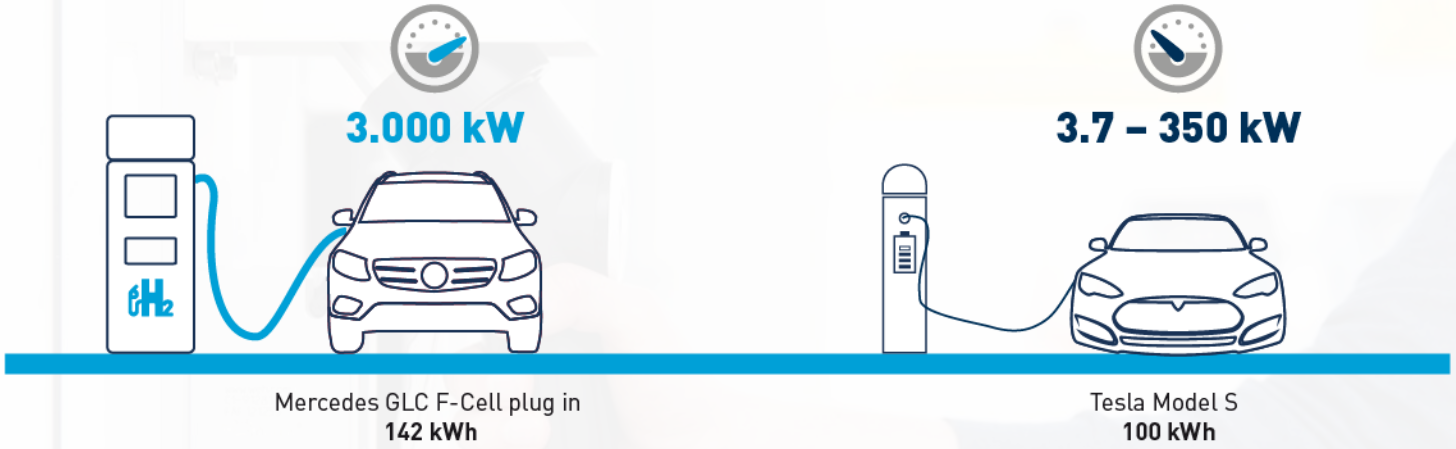
THE INVESTMENT IN PRODUCTION AND STORAGE OF 100% GREEN HYDROGEN DRIVES THE INVESTMENT IN THE H2 INFRASTRCUTRE AT 3 MIO VEHICLES

3 - 10 million EVs

Investment in 100% green hydrogen production from surplus electricity and storage. Relatively high investment due to low level of utilisation of assets.



THE SPEED OF THE REFUELLING PROCESS DRIVES THE ECONOMIES OF SCALE FOR HYDROGEN



The ultra-fast refuelling process drives the efficient use of the asset:

- ✓ **Time efficiency: more efficient use of production and refuelling assets**
- ✓ **Economics: greater turnover per time unit**

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	FCEV	BEV	
TIME TO REFILL	1	x10	A FCEV is refueled at 3.000 kW, future fast chargers will have up to 350 kW.
W2W EFFICIECY	1	x2	Energy efficiency of a BEV drivetrain including the battery is around twice as energy efficient as for FCEVs. However, this is under ideal conditions. In winter range of a BEV can be reduced by 40%, not for a FCEV.
WEIGHT	1	x100	The energy content of 5 kg of hydrogen is 150 kWh. A battery pack with 100 kWh weighs 100 times more. Not considered here: tank, structures.
INFRA COST			Better economies of scale, slower increase of investment with number of vehicles (FCEV). Production and storage included, H2 infrastructure is 11 bn EUR lower than for BEV. Both affordable at 40-50 bn EUR for Germany.
SHORT TERM COST			Batteries are affordable due to economies of scale (used in many applications like smartphones). FCs are still manufactured at much smaller scale. Hurdle to introduce high numbers of cars is lower for BEV.
VALUE CREATION			The number of parts manufactured in EU for FCEV is similar to ICE; for BEV more than 50% of value is the battery (automated, specialized, mostly from Asia).
RESOURCE NEED			Current Lithium-Ion batteries need Kobalt (65% of reserves in Kongo, difficult conditions); FCEV need Platinum, not more than ICE drivetrain in next gen. Needs further investigation.

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Thank you.

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