STRATEGIC ADVISORY
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TESLA BATTERY DAY 2020 –TECHNOLOGY ANNOUNCEMENT ANALYSIS

P3 technology report

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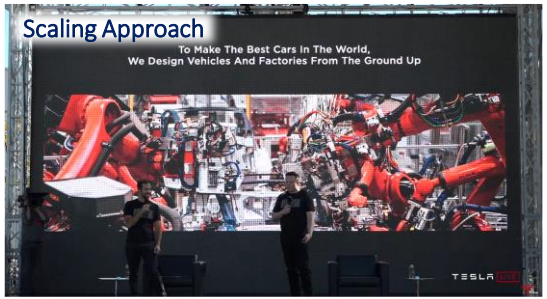
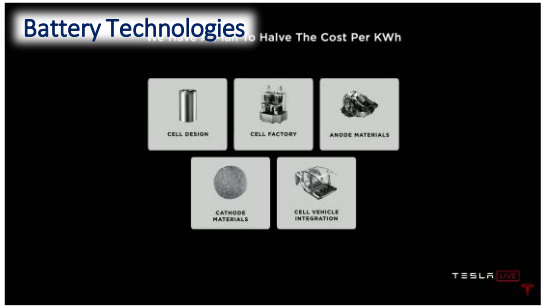
TESLA BATTERY DAY | P3 INSTANT ANALYSIS

Summary & Key Findings





KEY FINDINGS

- The battery day of Tesla has shown the directions for the potential Tesla is trying to achieve in the following key areas:
  - **Cell design** – a new cylindrical cell format 4865 w/ tables design to achieve higher energy densities and power rates at lower cost
  - **Cell factory** – implementation of dry electrodes and fully integrated cell assembly line with 10 times higher capacities at 86% reduced CAPEX
  - **Anode material** – development of Tesla own inhouse Silicon material and integrated manufacturing
  - **Cathode material** – announcement of developed cobalt free material combination and additional iron-phosphate design for stationary storage solution
  - **Cell to vehicle integration** – strong simplification of system design with direct cell to pack integration via honeycomb structures and thermal glues and fillers.
- **Additionally to these improvements**, which shall **drive battery system costs down by 56% and reduce CAPEX by 69% for battery manufacturing**, Tesla announced further strategic directions with recycling of cathode material, inhouse cathode material manufacturing, extraction of Lithium from the Nevada desert and many more.
- Details to these technologies are summarized on the following pages of this report.

All images @ Tesla Shareholder Meeting & Battery Day 2020

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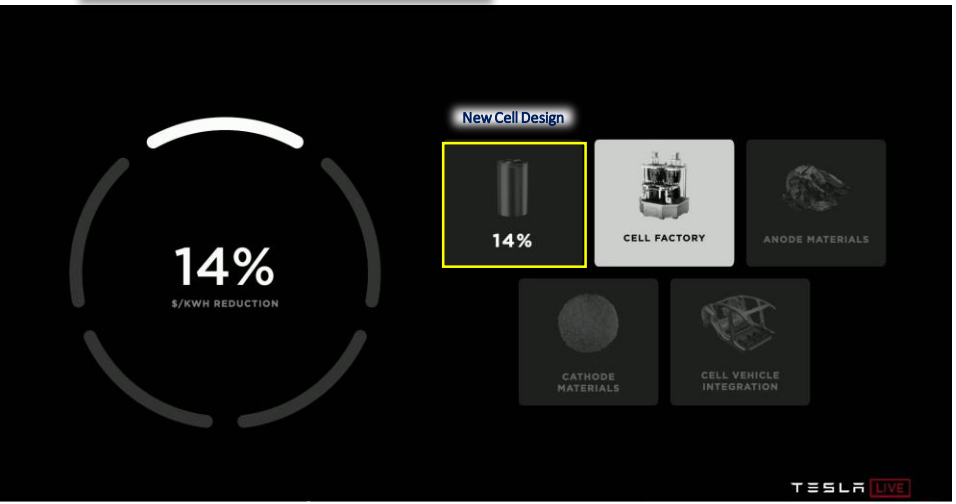
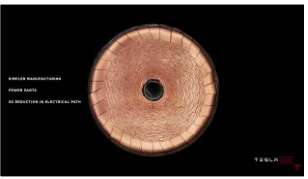
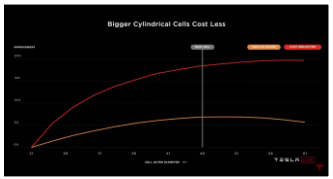
Cell design: Tesla presents new cell design and dimensions, which is fully optimized regarding vehicle range, cost reduction and power capability. The new cell concept is tab free to enhance power and charging capabilities, while the new dimensions will increase the energy density and reduce cost.

1 | CELL DESIGN







KEY FINDINGS

- **Cell dimensions** are enlarged to **46mm outer diameter** and **80mm length** (2170 to 4680)
- The new cell design will **reduce** the cell **manufacturing effort**, due to **no additional tab**, which doesn't need to be laser welded to the can.
- This process needs **less steps and less parts** in total
- **Sides of the electrode sheets** are **laser welded at the bottom** together to connect them to the cell can and increase the conductivity.
- **Electrical pathway** is **shortened** by five times and **reduce** the **inner resistance**.
- Also the **range** is **increased by 16%** due to higher energy density on the battery system level.
- New cell dimensions will **increase the energy content fivefold**.
- **Production** already **running in the pilot 10 GWh factory**, which will ramp up in one year.
- Overall improvement in cell design and dimension leads to a cost **reduction of 14% in USD/kWh**.

All images @ Tesla Shareholder Meeting & Battery Day 2020

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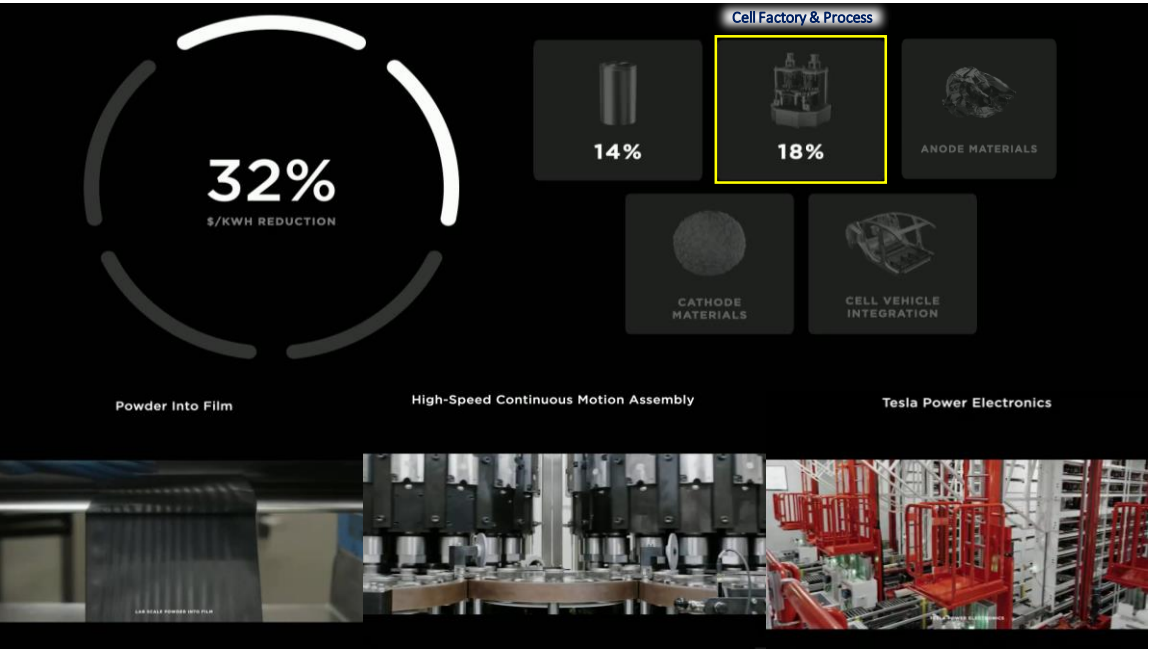
Cell factory: Tesla announced innovations throughout the entire battery cell production process to achieve a fast, low cost process at a planned scale of 1 TWh (1,000 GWh).

2 | CELL FACTORY



KEY FINDINGS

- Tesla has announced a **reduction of battery system costs by 18%** through optimized cell manufacturing processes.
- With application of new technologies Tesla has announced to be able to produce 20 GWh on a single assembly line to pave the way towards new "Tera"-factories (1,000 GWh).
- **Electrode manufacturing, cell assembly and formation** have been improved compared to previous process designs.
- **Electrode process:** Tesla optimized **Maxwell's dry coating** process and applied it for electrode production. Dry processing should enable electrode production with a significantly **smaller footprint & higher throughput.**
- **Cell assembly:** Tesla & Tesla Grohmann automation **have fully automated the cell assembly** to maximize throughput.
- **Formation:** Tesla announced massively **reduced footprint (75%) and investments (-86%)** for formation essentially resulting in significantly **reduced formation time per cell.**

All images @ Tesla Shareholder Meeting & Battery Day 2020

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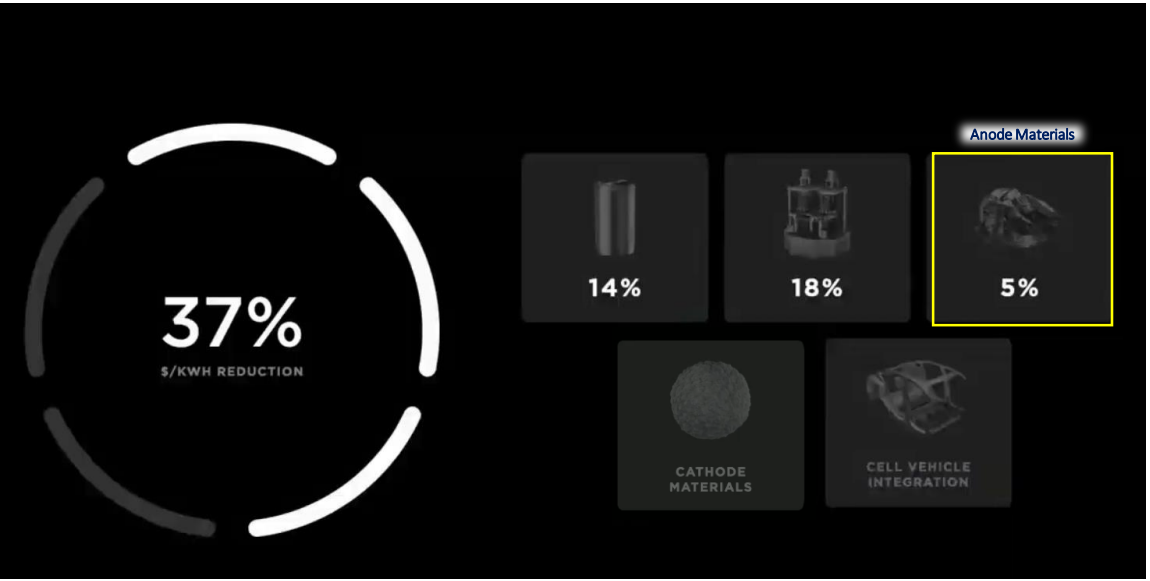
Anode: The implementation of a novel anode material was announced to contribute to 5% lower battery costs. The Silicon based anode material will be optimized by an elastic binder and increase the range by 20%.

3 | ANODE MATERIALS



KEY FINDINGS

- Application of **Silicon** which stores **9 x more lithium** than graphite
- **Challenge of volume expansion** currently countered by highly engineering and expensive approaches on material level. Current technologies cost from 6.6 $/kWh
- Tesla's novel Silicon anode material was announced to be **outstandingly cheap at 1.2 $/kWh** (compared from 6.6 to over 100 $/kWh for competitive technologies.)
- The material will be **designed for expansion**, raw Silicon will be used. The material is produced by stabilizing raw silicon through **elastic ion-conducting polymer coating.**
- Silicon anode was announced to **increase vehicle range by 20%.**

All images @ Tesla Shareholder Meeting & Battery Day 2020

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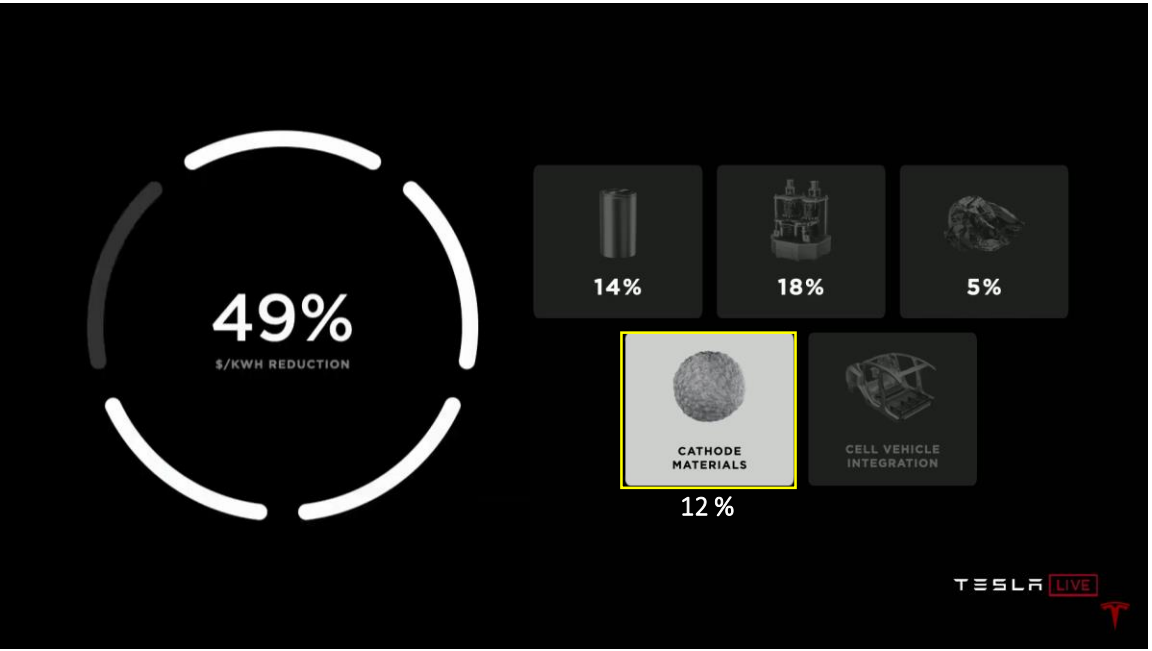
Cathode: 12% in $/kWh reduction through full integration into CAM manufacturing w/ Cobalt-free designs and diversified approach for different products. In-house recycling and access to Nevada Lithium sources for localized material value chain are further drivers for improvements and sustainability.

4 | CATHODE MATERIALS



KEY FINDINGS

- **Maximize Nickel and full removal of Cobalt** in cathode
- Novel **coatings** and **dopants announced**
- **Diversified cathode approach** (LFP for long cycle life/ entry models/ stationary, Nickel Manganese for Long Range/ Medium+, High Nickel for Premium/ trucks)
- Full integration into **CAM manufacturing** incl. radical process and **cost reduction** (-66% CAPEX, -76% process costs, no wastewater and 100% electricity powered)
- Utilization of **lower grade Nickel** feasible and production of Nickel intermediates omitted
- **Localized upstream supply chain** for cathode in the U.S. allows for significant logistics effort reduction
- **Co-location** of **Lithium conversion** directly to CAM and cell manufacturing (-33% costs, 100% electrically powered)
- Access to tremendous **Lithium reserves** in clay in **Nevada** (TWh scale up possible); very easy access via acid-free saline extraction currently in development
- **In-house LIB recycling established and** operations starting from Q1/2021

All images @ Tesla Shareholder Meeting & Battery Day 2020

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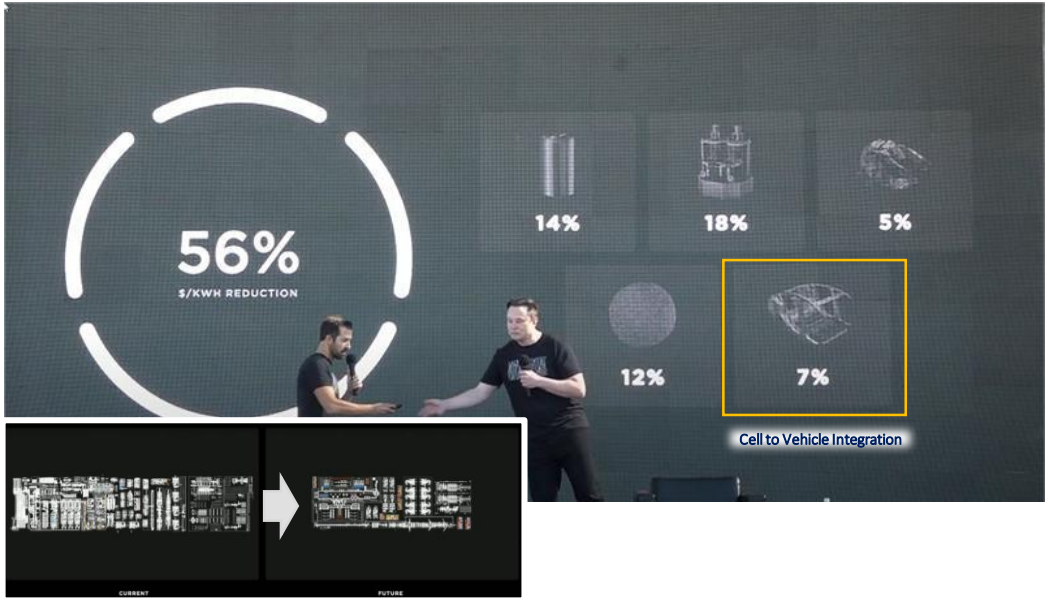
Cell vehicle integration: Tesla announces an enormous weight reduction of its vehicle architecture based on a structural battery - resulting in a good cost reduction and reduced assembly effort.

5 | CELL VEHICLE INTEGRATION

- Optimization on cell integration into the vehicle will contribute by 7% to the overall 56% cost reduction



KEY FINDINGS

- Tesla announces **cost savings of 7%**, an **investment per GWh** reduction by **8%** and a **range increase by 14%** just through optimizations in vehicle integration.
- In first step, the **Model Y** Giga shall have **79 less parts** and **costs** for the **rear underbody** shall be **reduced by 40%**.
- Further improvements include the **manufacturing** of the **front car element** as a single component made of a **new alloy** which does not require any heat treatment/ coating.
- By this the **battery pack** itself can work as a **structural element**. Additionally the pack is filled with a glue/ adhesive to **increase pack stiffness** by a “honeycomb” structure
- Based on the structural battery design, Tesla claims a **10% mass reduction** lowering components by 370. This enables a **14% increase in range**.
- As a consequence of the new product design, the **manufacturing** shall be **simplified** so that the **CAPEX per GWh** can be **reduced by 55%**.

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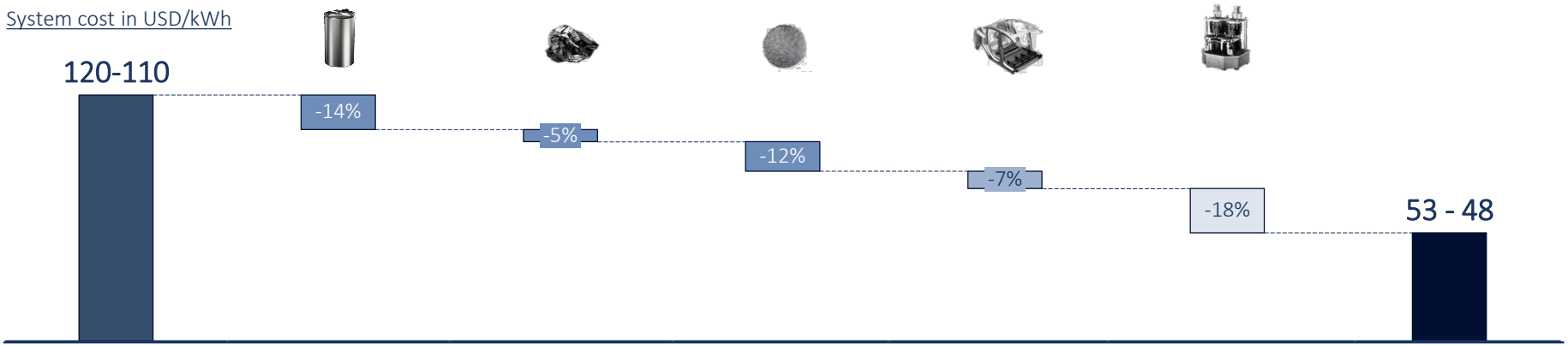
Summary Cell Cost Improvements: The combination of innovations within the cell design, active materials, vehicle integration and simplified TWh scale manufacturing will reduce cell costs dramatically.



Current Battery System Cost	Cell Design	Anode Material	Cathode Material	Cell to Vehicle Integration	Cell Factory	Future Battery System Cost
Current Tesla Model 3 2170 cell & pack	Change from 2170 to 4680 cell format w/ reduced housing	Tesla inhouse high energy density silicon material usage	High Ni, low Co CAM[1)] w/ novel coatings and increased manganese	Simplified cell2pack w/o intermediate structure	Dry coating process w/ low energy consumption	Target cost performance for 2024/2025
Already best in class cell chemistry w/ 92% High-Ni NCA	New tabless electrode design for improved dis-/charging	Polymer coated particles w/ highly flexible binder	Collocated inhouse CAM manufacturing for minimal cost	Cells as structural element glued within pack	High speed continuous motion assembly	Almost 100% inhouse manufacturing
Today´s evaluated cell costs at 95 – 100 USD/kWh	5x energy, 6x power, +16% range compared to 2170 design	1.2 USD/kWh material cost for inhouse Anode material	Sulfate free CAM production process	Simplified manu-facturing -25% CAPEX, -35% floorspace	1 line w/ 20 GWh output, 3 TWh total installed capacity in 2030	Global manufacturing footprint established

[1)]CAM = Cathode Active Material

DISCLAIMER

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