

# Heating Rate

## Pouch and Cylindrical 18650 Cells

Presented to:

By: Matthew Karp

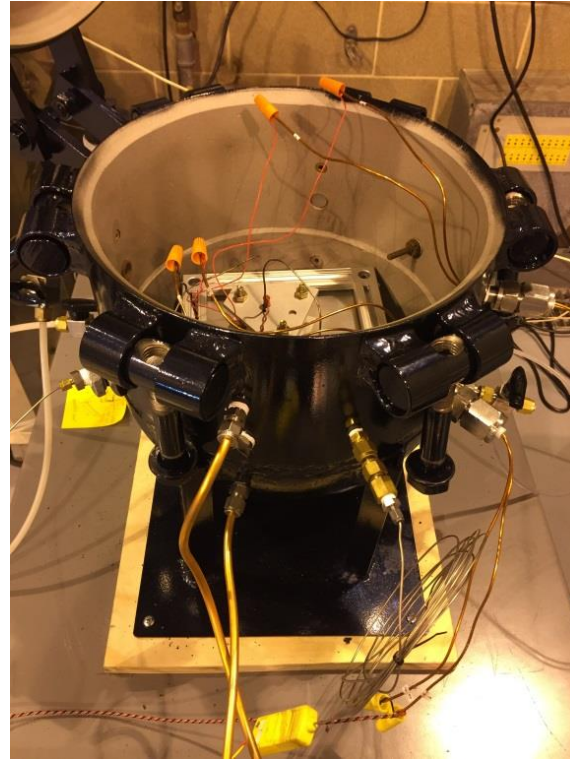
Date: December 2020



**Federal Aviation  
Administration**

# Test Apparatus

- 21.7 liter stainless steel pressure vessel
- General test procedure found [here](#)

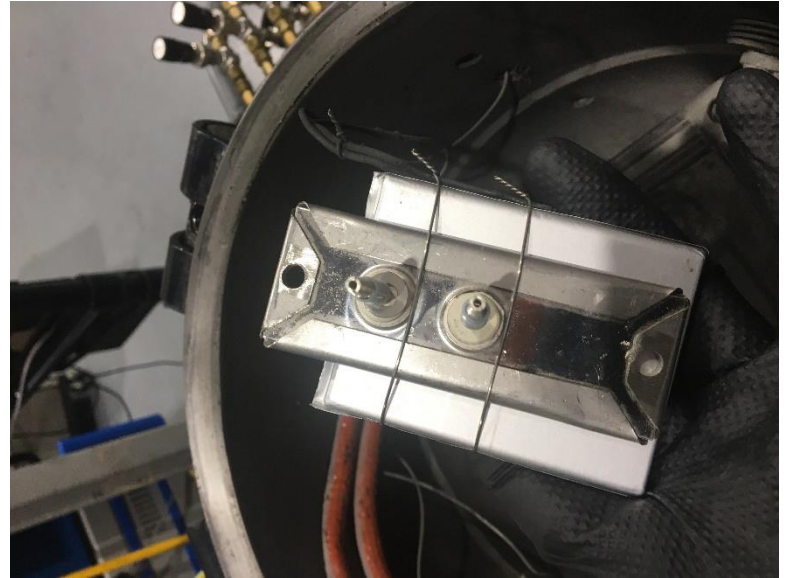


# Scope of Test

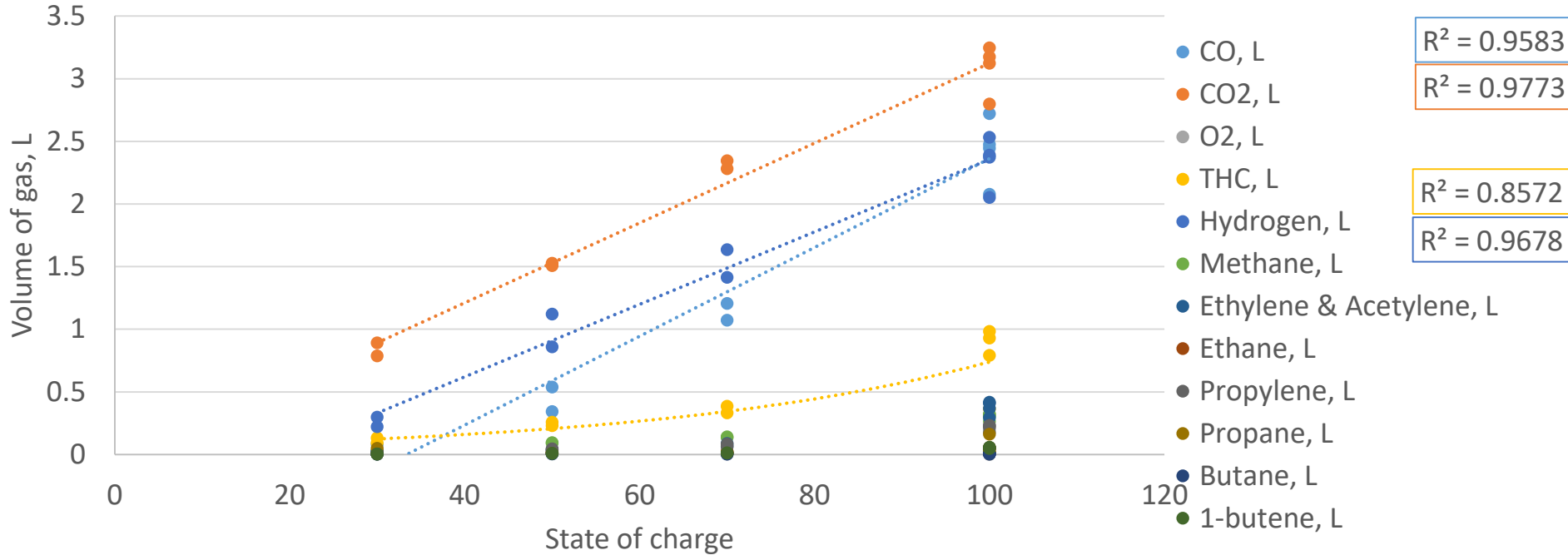
This study experimented with pouch and cylindrical style lithium-ion cells to determine the effects of heating rate on a cell's thermal runaway across various states of charge.



# Test Setup

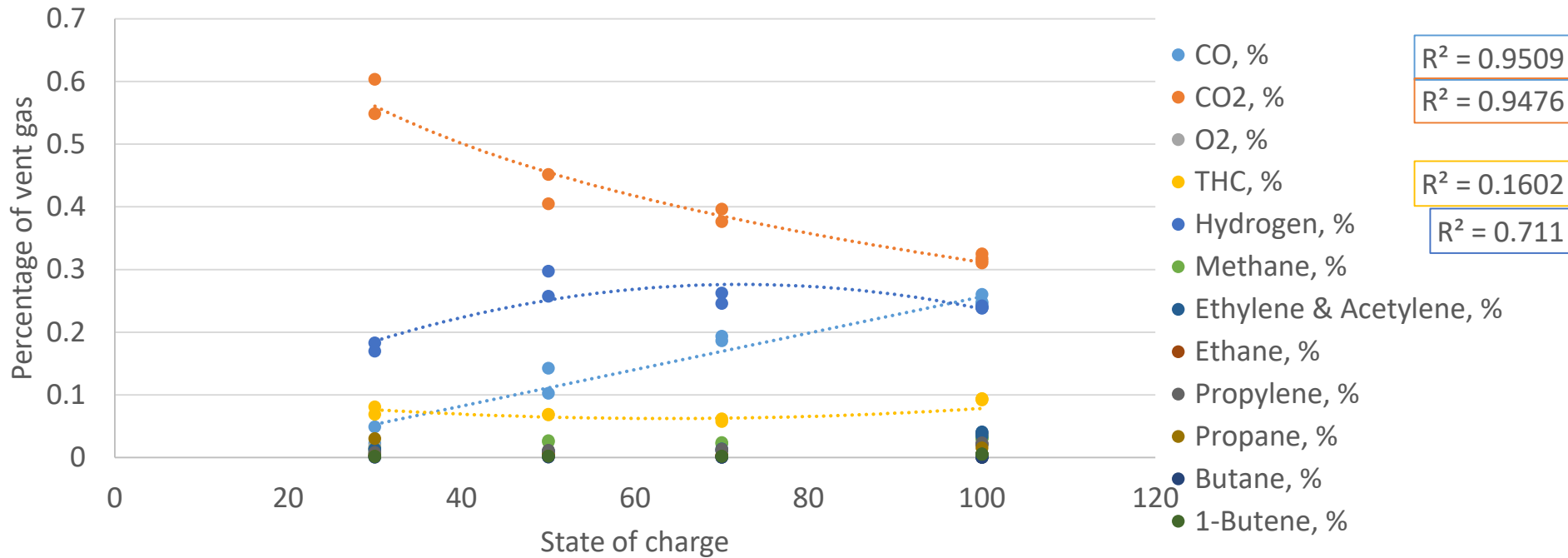


# Results – Pouch Cells



Volume of vent gas vs state of charge

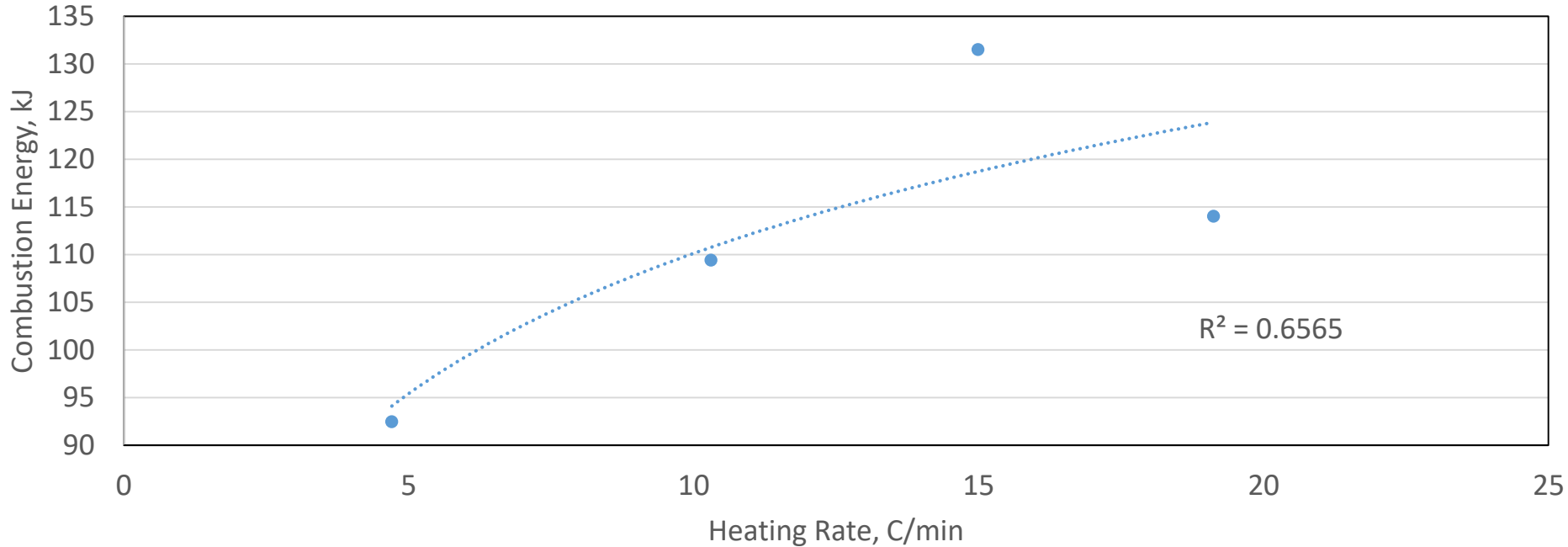
# Results – Pouch Cells



Percentage of vent gas vs state of charge



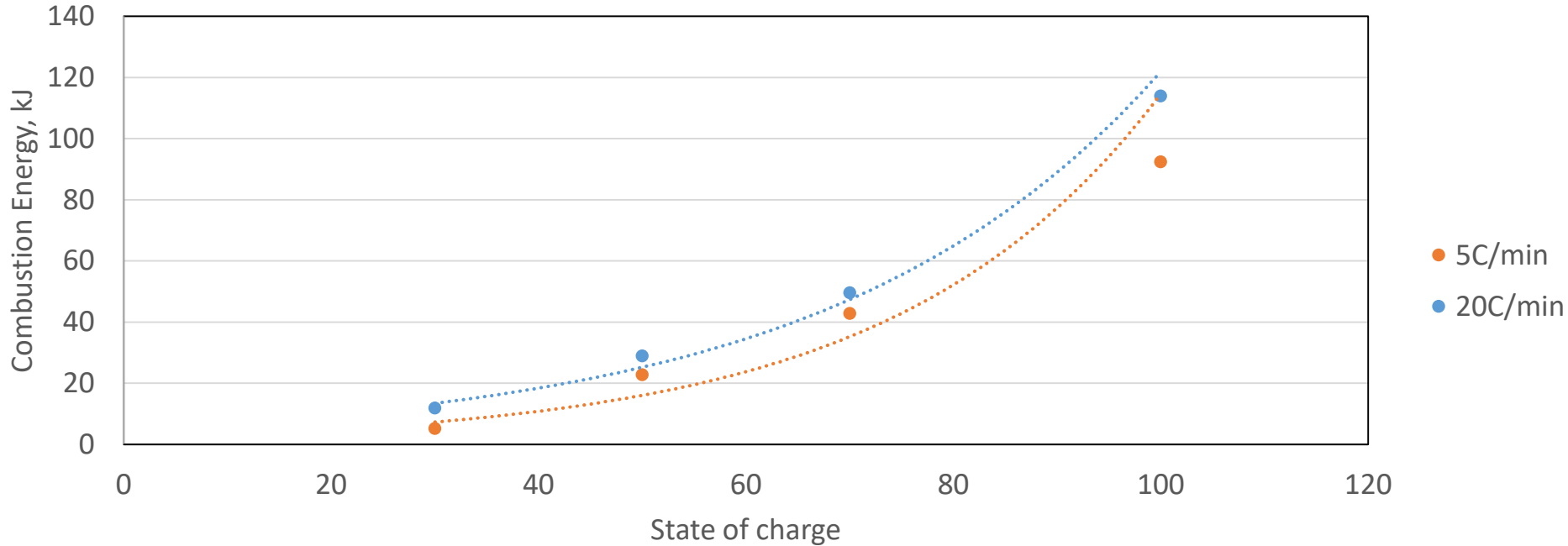
# Results – Pouch Cells



Combustion energy if ignited vs heating rate at 100% SoC



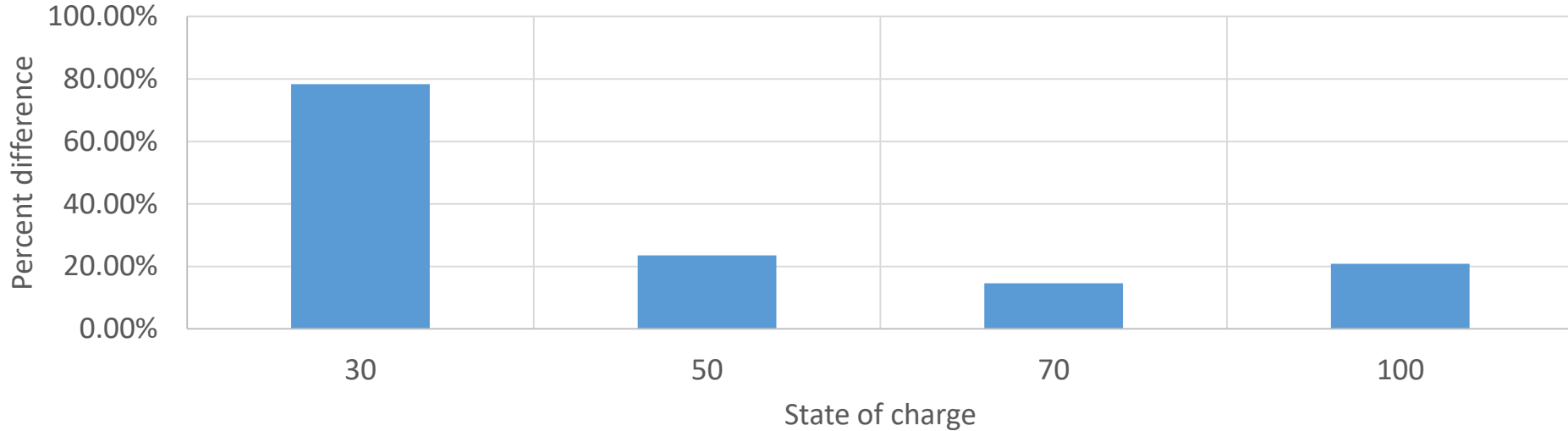
# Results – Pouch Cells



Combustion energy if ignited vs state of charge by heating rate



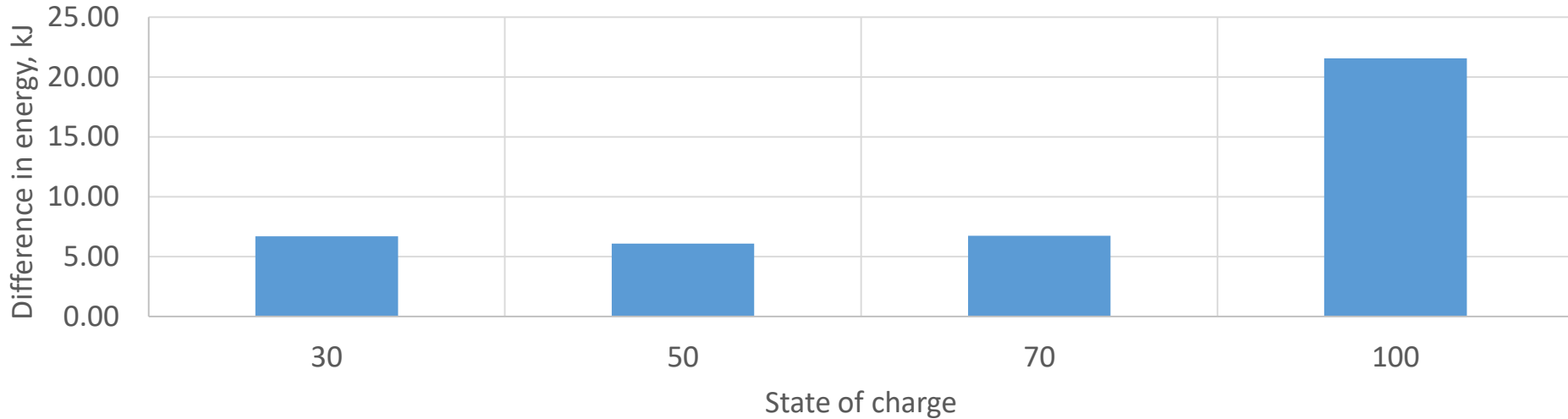
# Results – Pouch Cells



Percent difference in combustion energy by heating rate (20C/min and 5C/min) vs state of charge



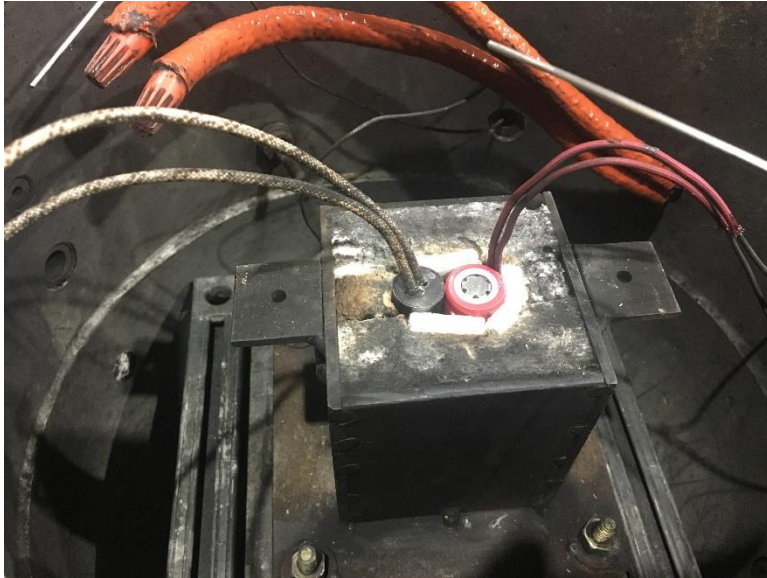
# Results – Pouch Cells



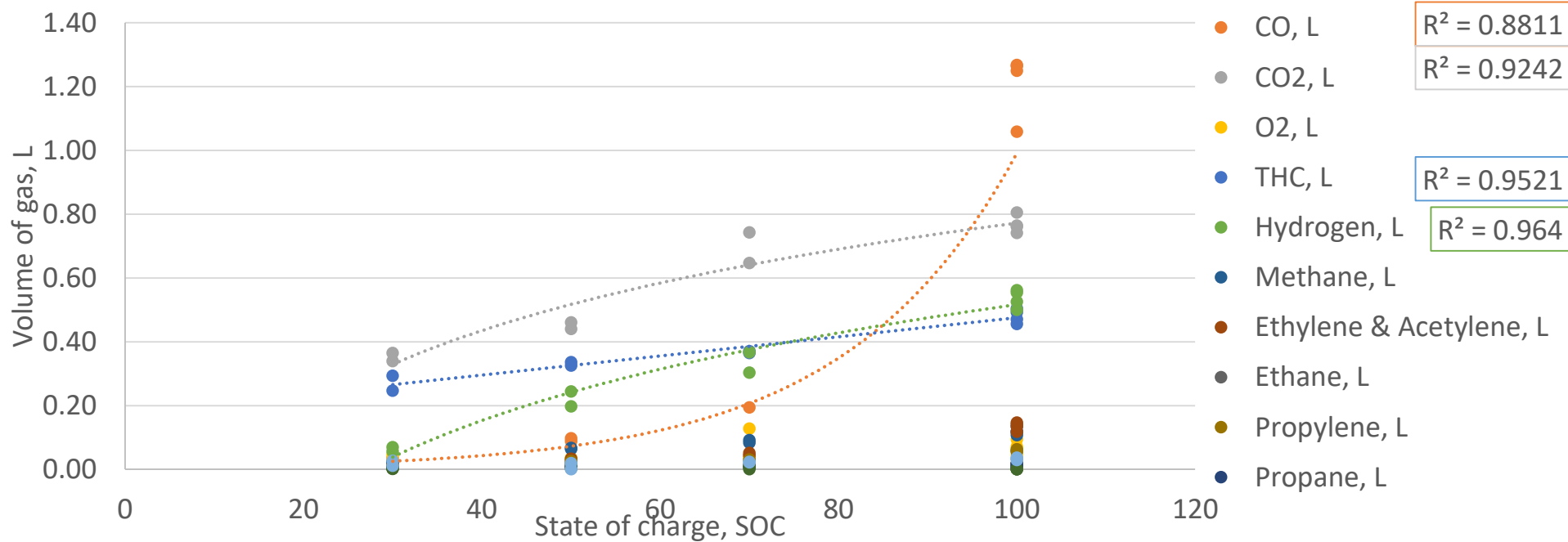
Total difference in combustion energy by heating rate (20C/min and 5C/min) vs state of charge



# Test Setup

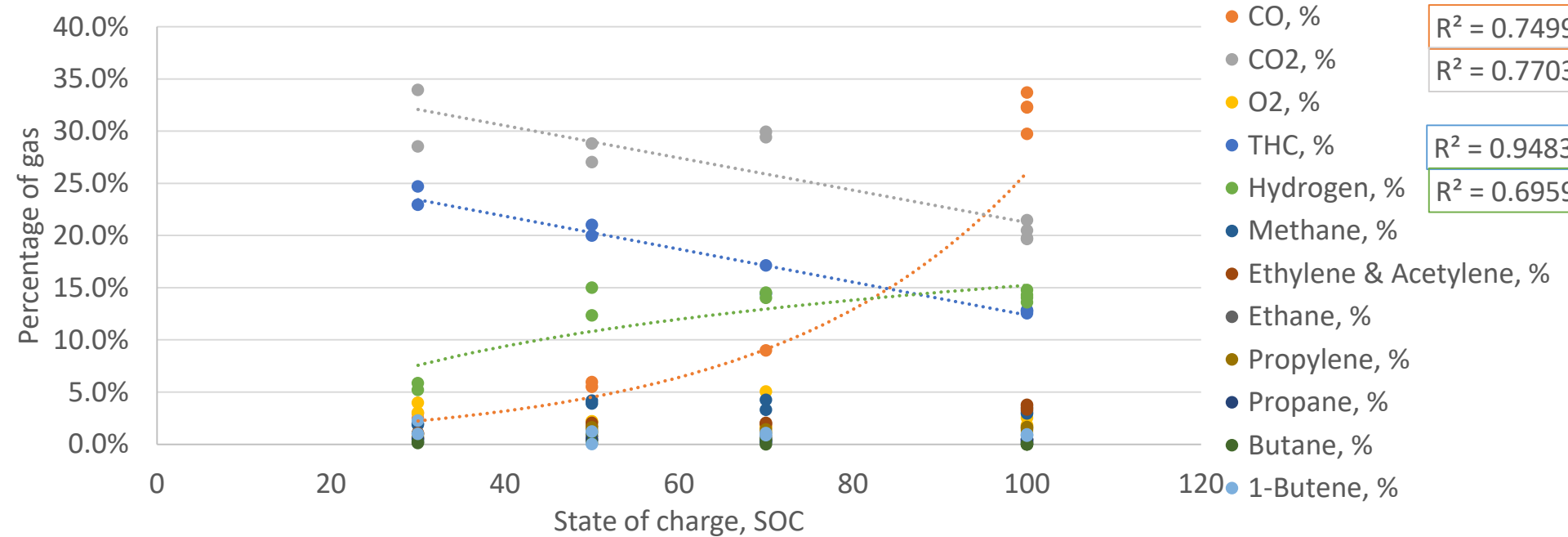


# Results – 18650 Cells



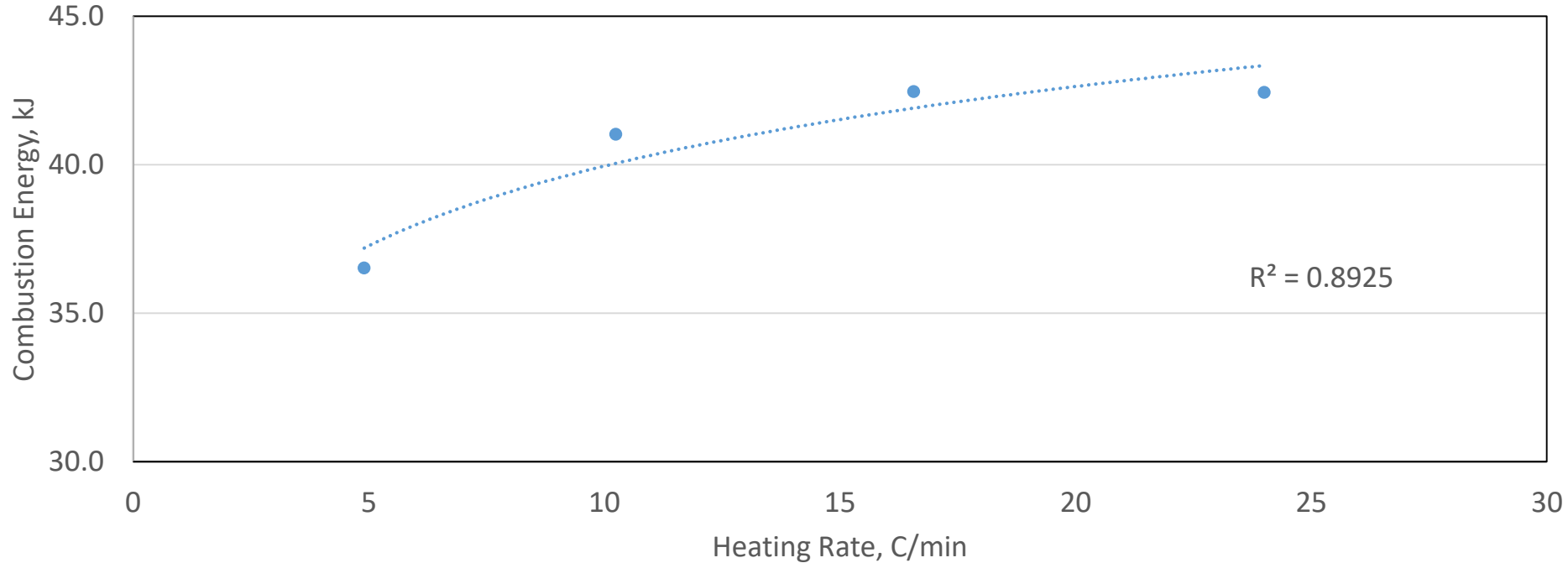
Volume of vent gas vs state of charge

# Results – 18650 Cells



Percentage of vent gas vs state of charge

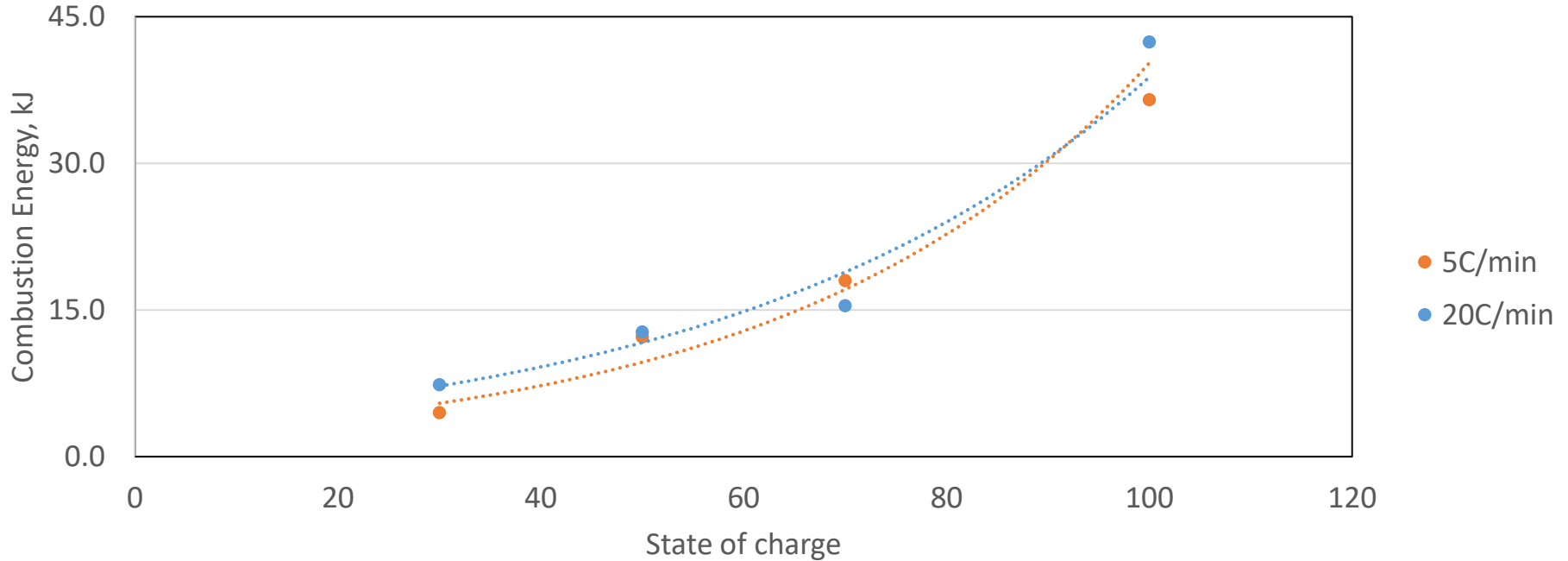
# Results – 18650 Cells



Combustion energy if ignited vs heating rate at 100% SoC



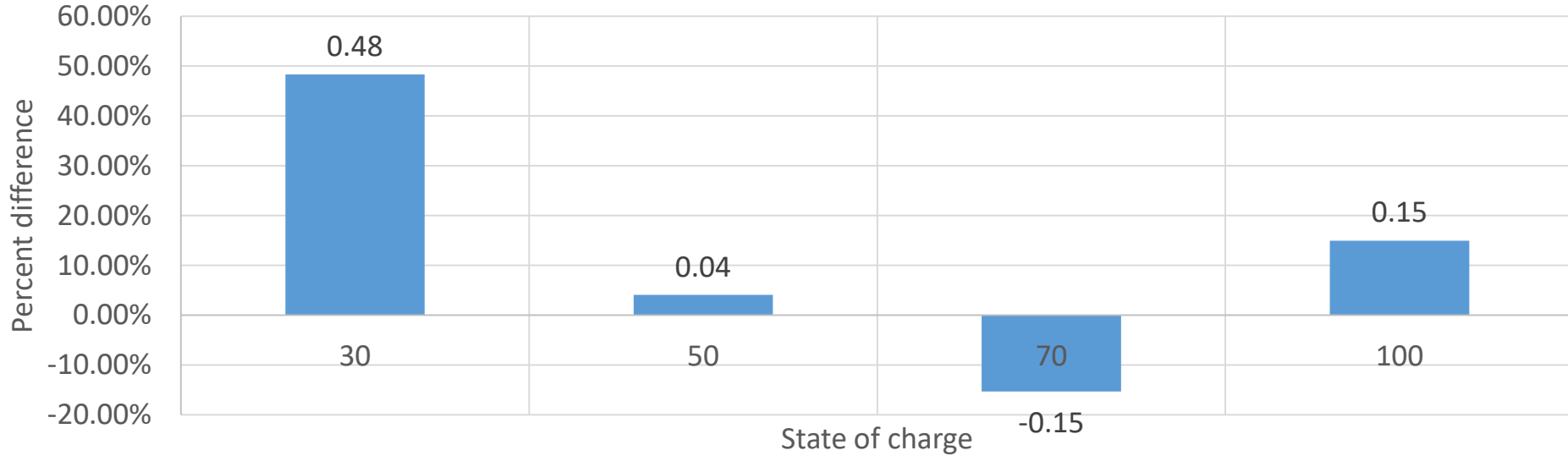
# Results – 18650 Cells



Combustion energy if ignited vs state of charge by heating rate



# Results – 18650 Cells

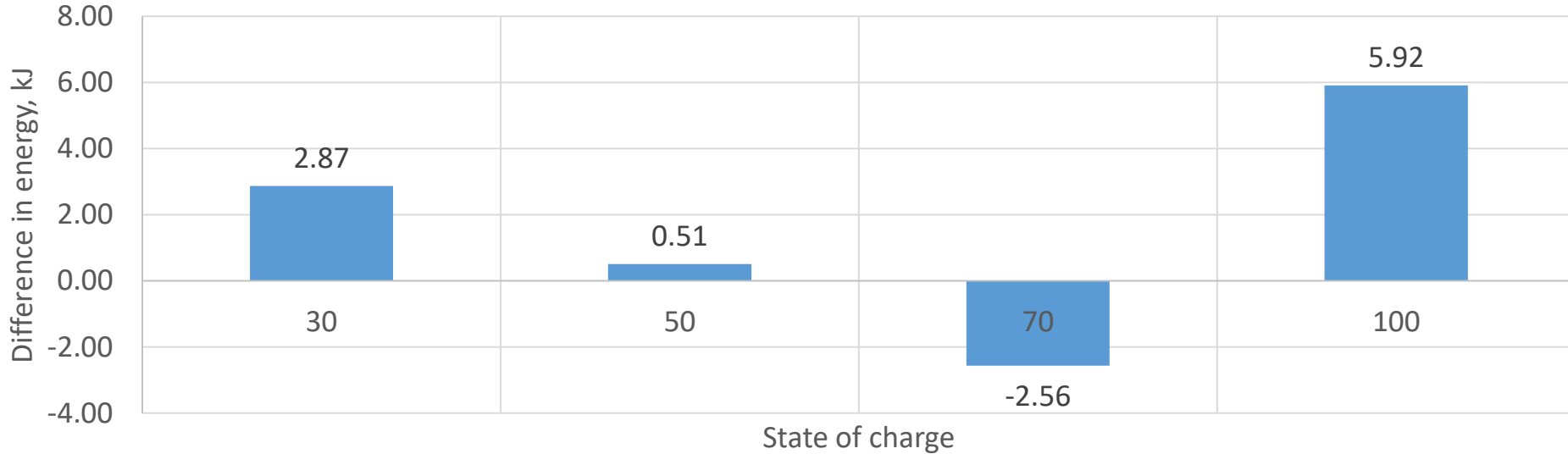


Percent difference in combustion energy by heating rate (20C/min and 5C/min) vs state of charge





# Results – 18650 Cells



Total difference in combustion energy by heating rate (20C/min and 5C/min) vs state of charge



# Conclusion

- Heating rate affects the combustion hazards due to thermal runaway, especially at lower states of charge
  - More data required to confirm hypothesis for higher SOC
- It is important to test in nitrogen to measure the combustion hazard

