Electro Static Precipitators Optimization and Issues: Case Study Recovery Boilers

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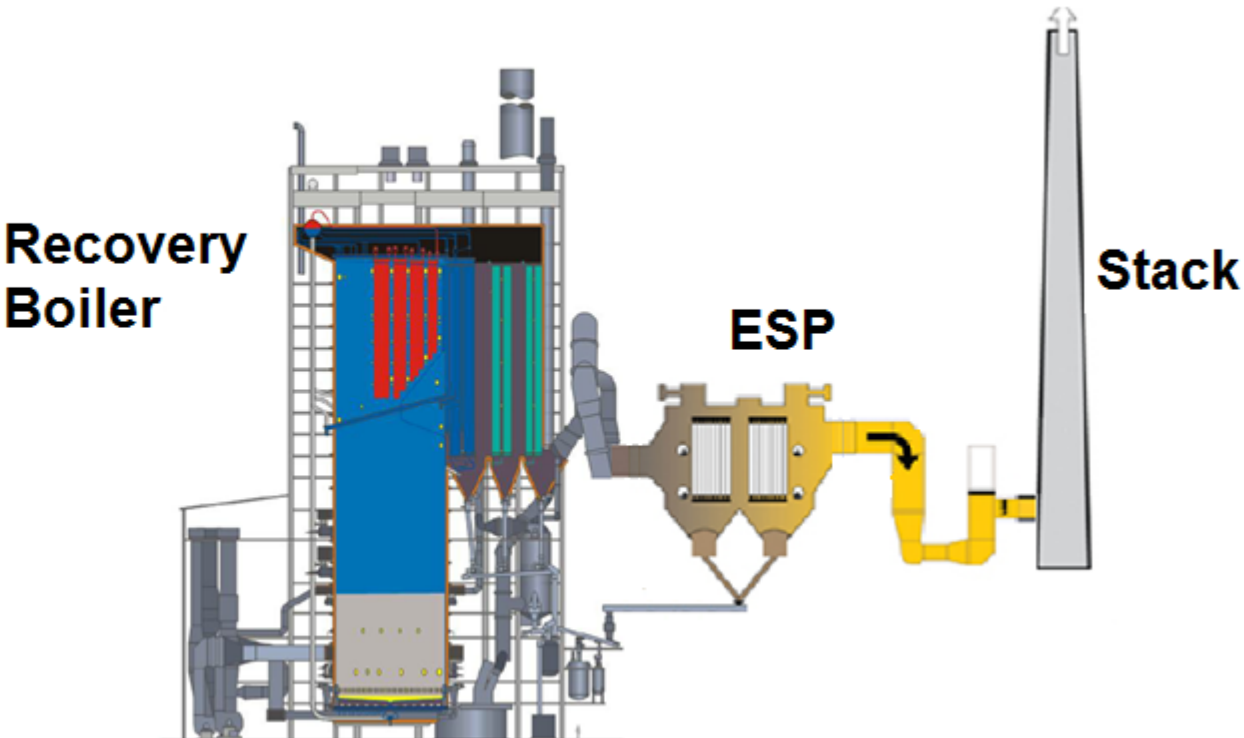
Emission Reduction Controls and Strategies
-Guelph-

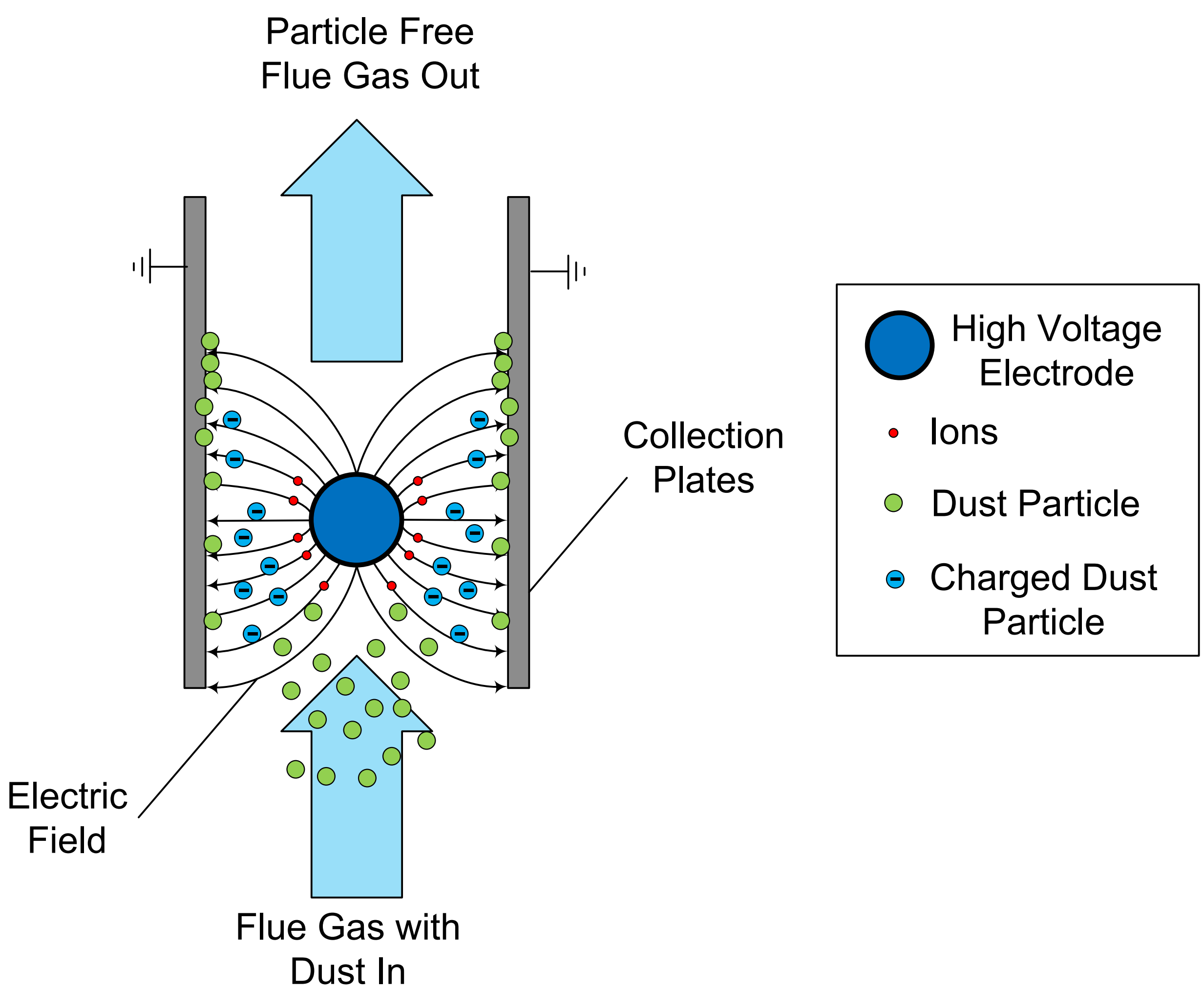
Electrostatic Precipitators (ESP)

- Filtration devices to remove fine particulate from gases (smoke, dust), or collect valuable material
- Electrostatic attraction to remove particulate matter



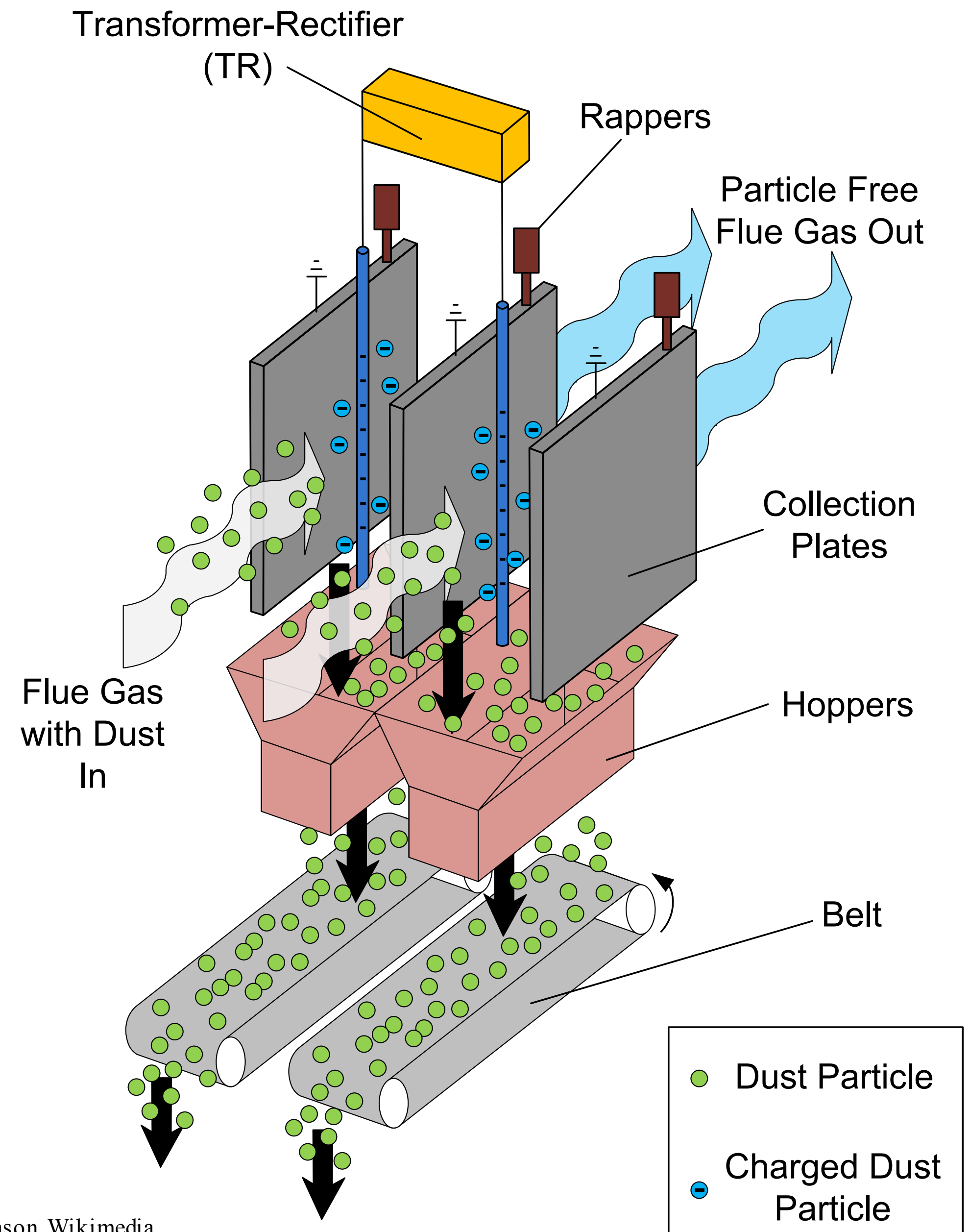
Courtesy of Valmet

ESP Operating Principles



ESP Full Setup

- Precipitator
- Ash Removal

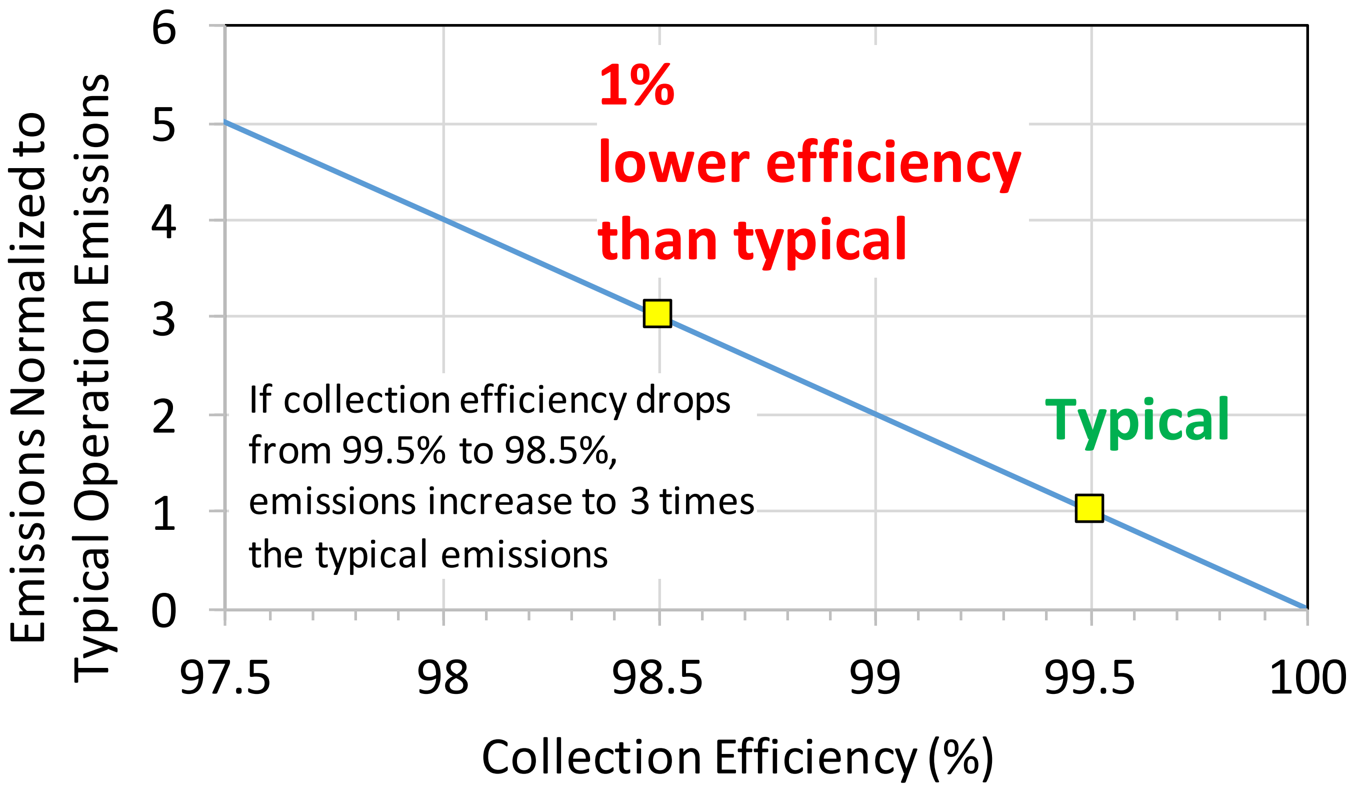


(Adapted from "Conceptual diagram of an electrostatic precipitator" by E. Mason, Wikimedia Commons licensed under CC BY-SA 3.0)

Advantages of ESP

- Treat large volume flow rates of flue gas
- Low pressure drop
- Robust
- High particle removal efficiency (>99.5%)

Problems of ESP



- **Reduction in efficiency from:**
  - **Poor removal of buildup**
  - **Changes in properties of flue gas and ash**

Past Work

- Computer Models
- Full scale studies
- Lab scale studies

Coal and biomass boilers

(Oxides)

- Resistivity of ash
- Full scale study

Recovery boiler

(Alkali Salts)

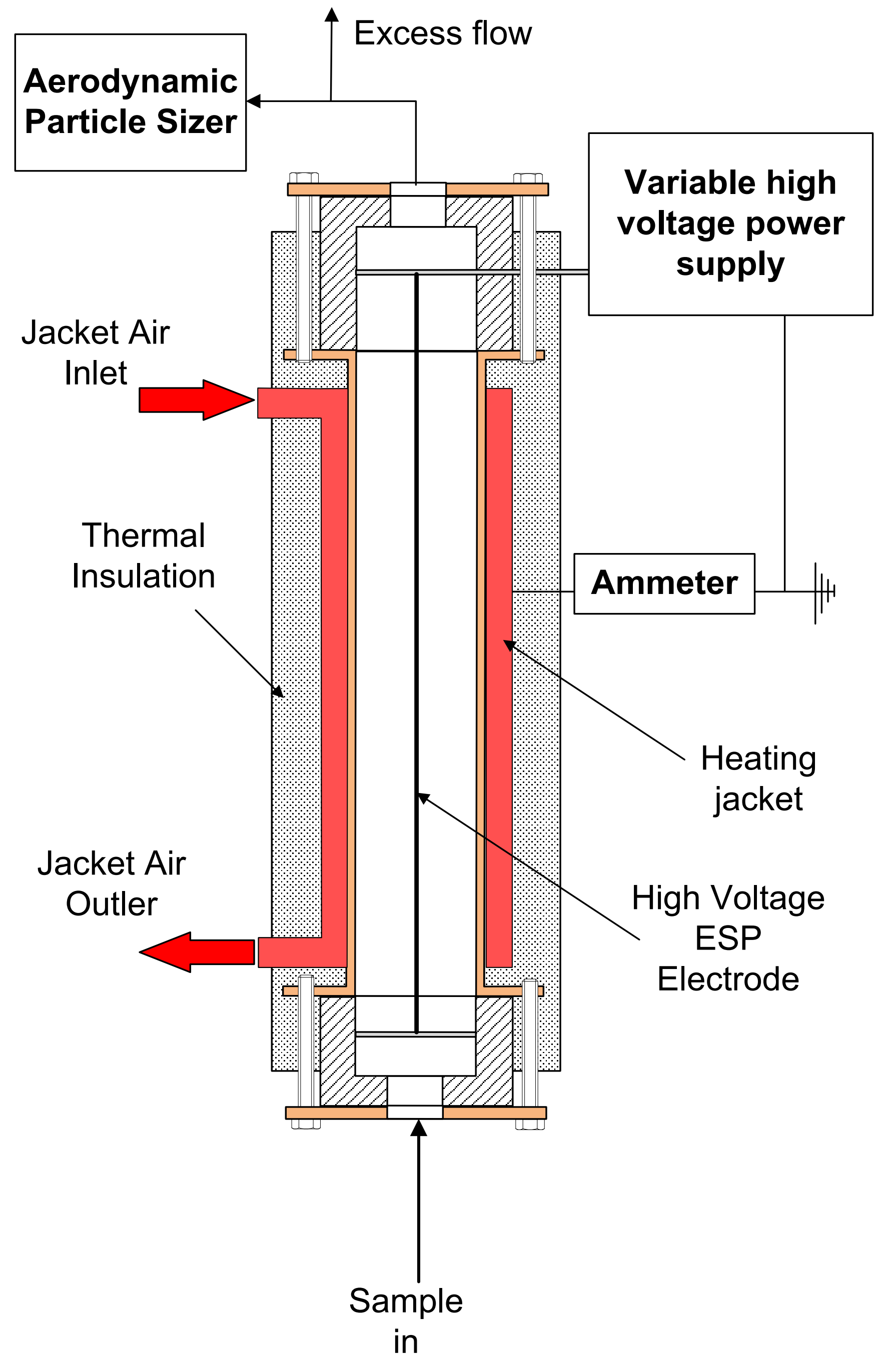
Objectives

Measure the efficiency under different recovery boiler operating conditions, and determine how each affects performance

- Design and Validate bench scale ESP
- Use setup Investigate effect on collection efficiency of
    1. Particle composition
    2. Flue gas condition (Temperature and Moisture content)

Bench Scale ESP

- **Aerodynamic Particle Sizer (APS)**
  - **Particle number concentration**
  - **Particle size distribution (0.3-10μm)**
  - **Typically used for ambient air measurements**
- **Heating Jacket to control ESP temperature**
- **Ammeter to measure current through ESP**



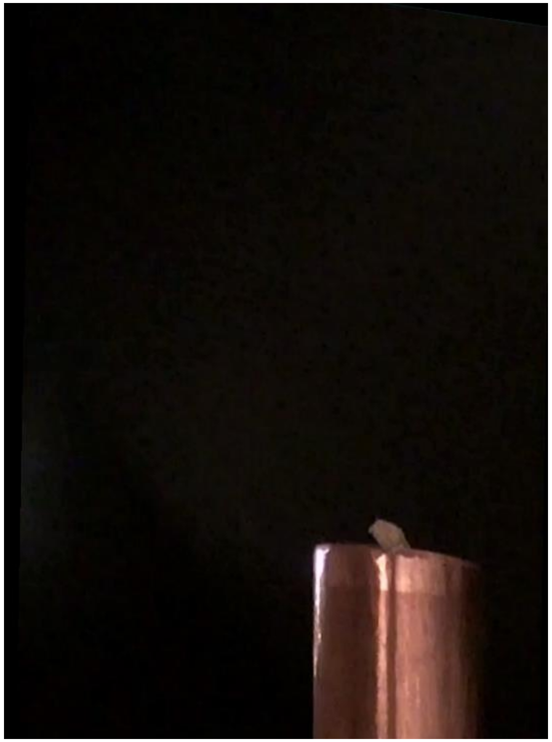
Bench Scale ESP Proof of Concept

Smoke Generated from Smoldering Wood

No Voltage

Thick Smoke Visible

High Voltage



No Smoke Visible

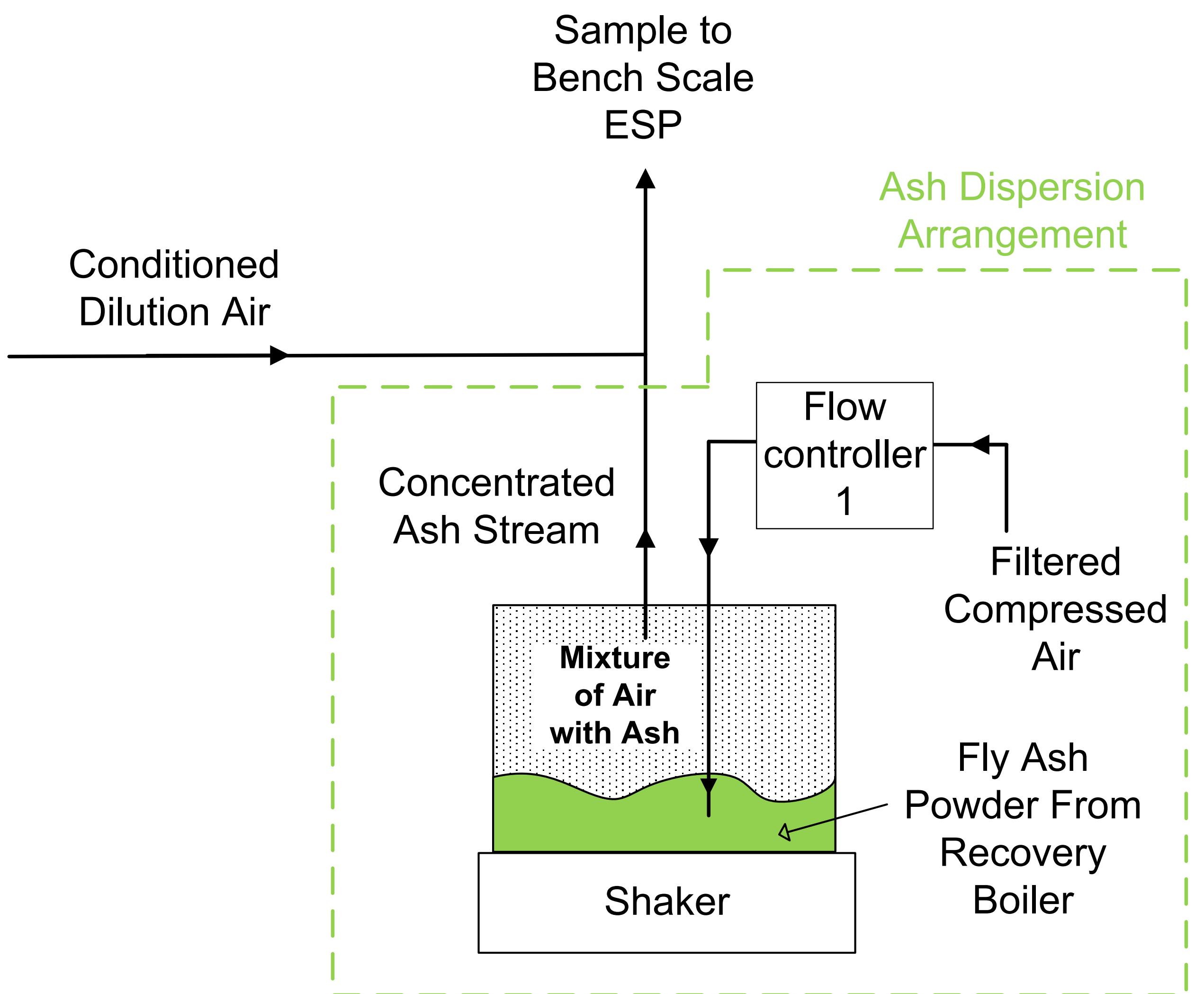
Arcing Audible

Low Voltage

Some Smoke Visible

Arcing Less Frequent

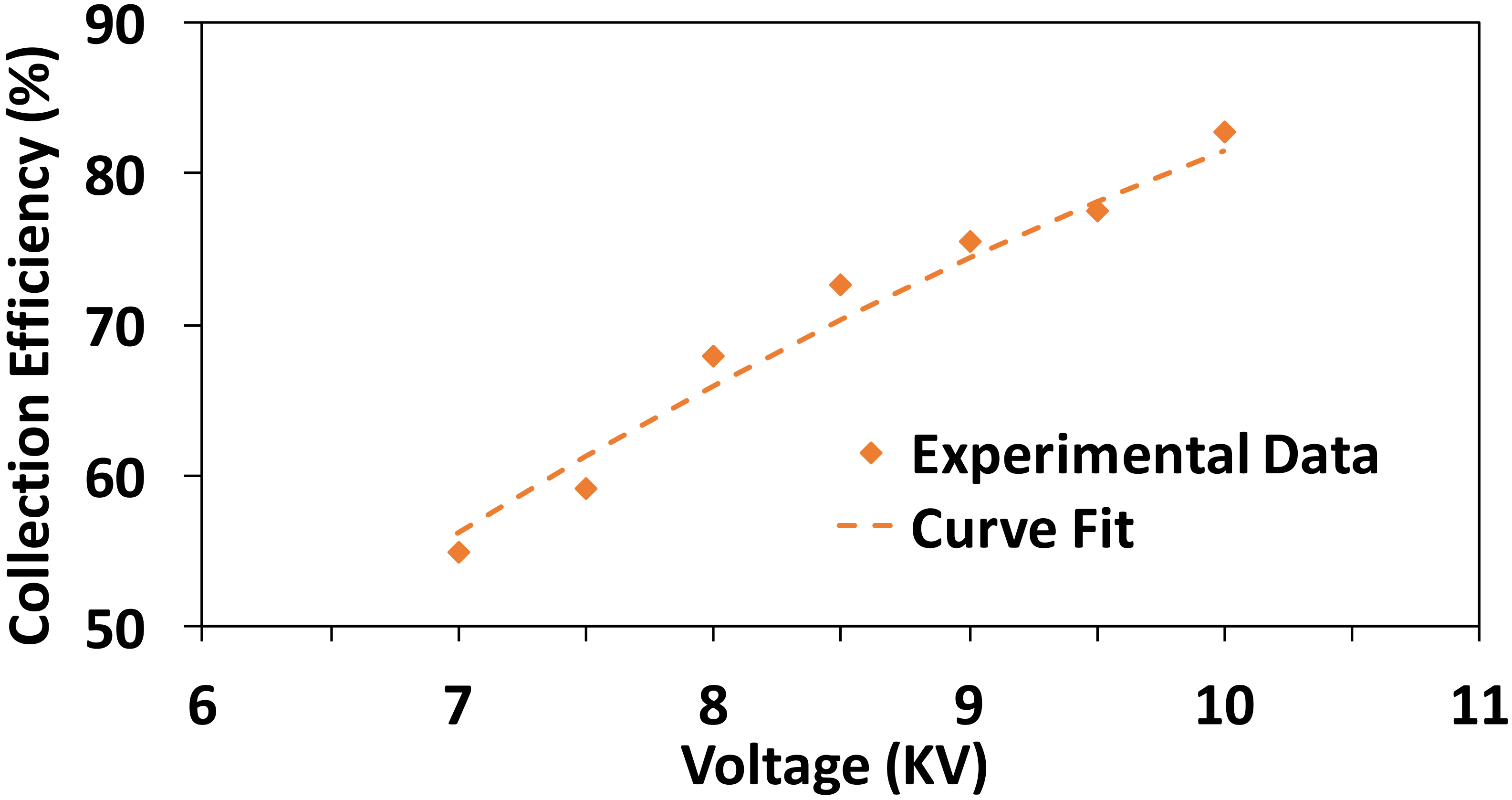
Sample Generation Using Ash From Full Scale ESP



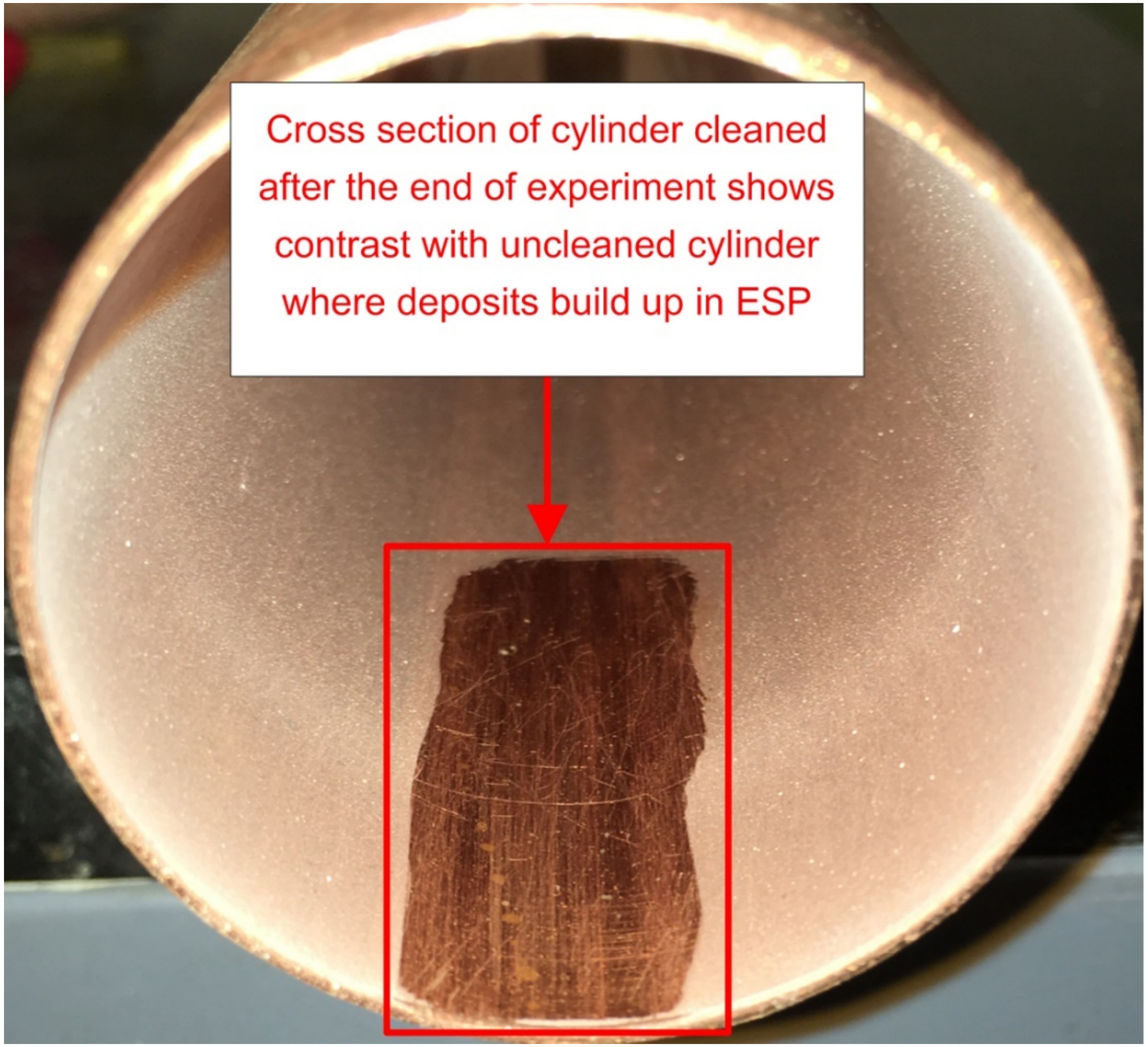
Bench Scale ESP Validation

Curve fit: $\mathrm{Eff} = \left[1 - \mathbf{exp}^{\left(-0.0168\times \mathrm{voltage}^2\right)}\right]\times 100$

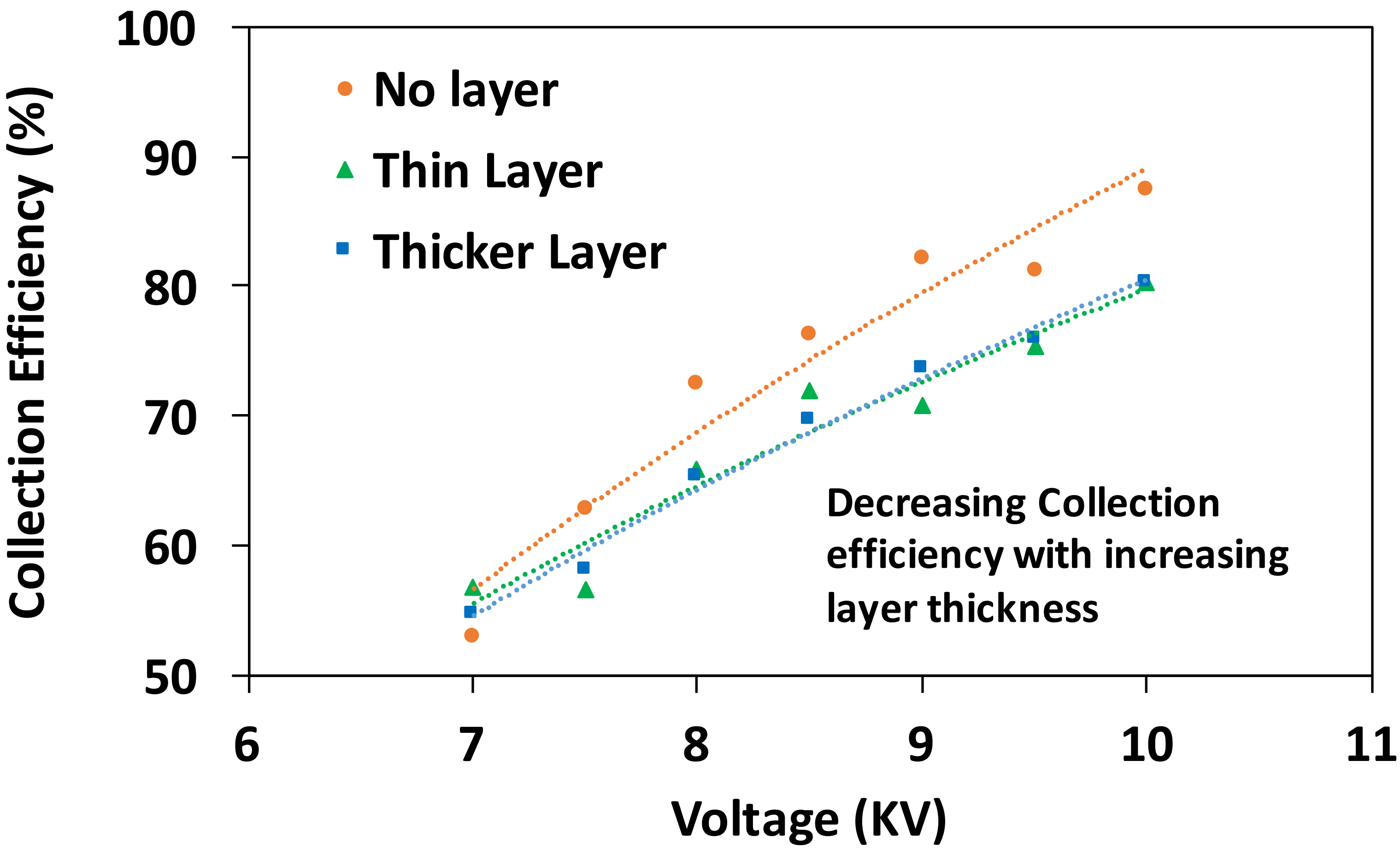
$R^2 = 0.961$



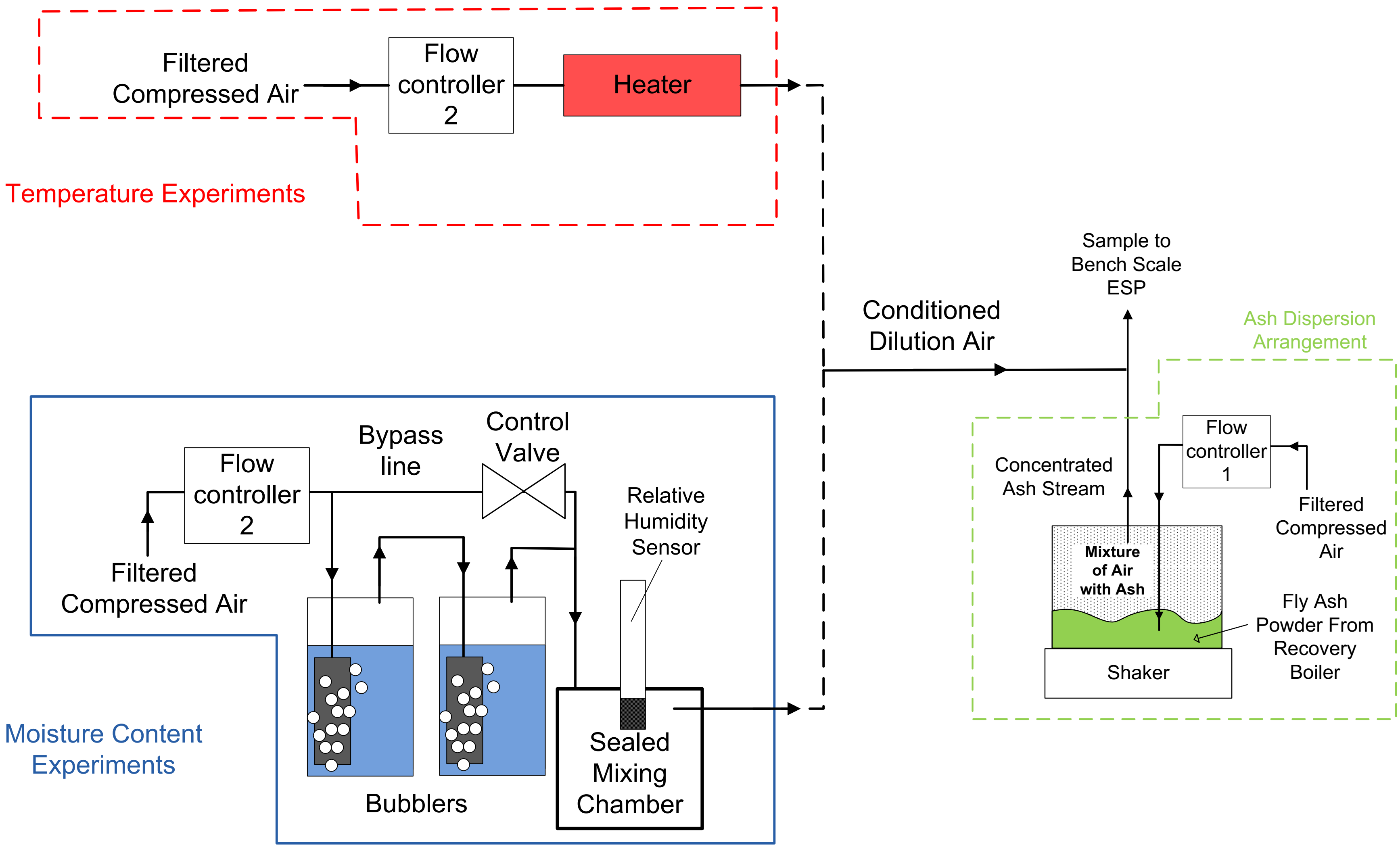
Buildup on ESP Collection Plate



Effect of Buildup on Collection Efficiency



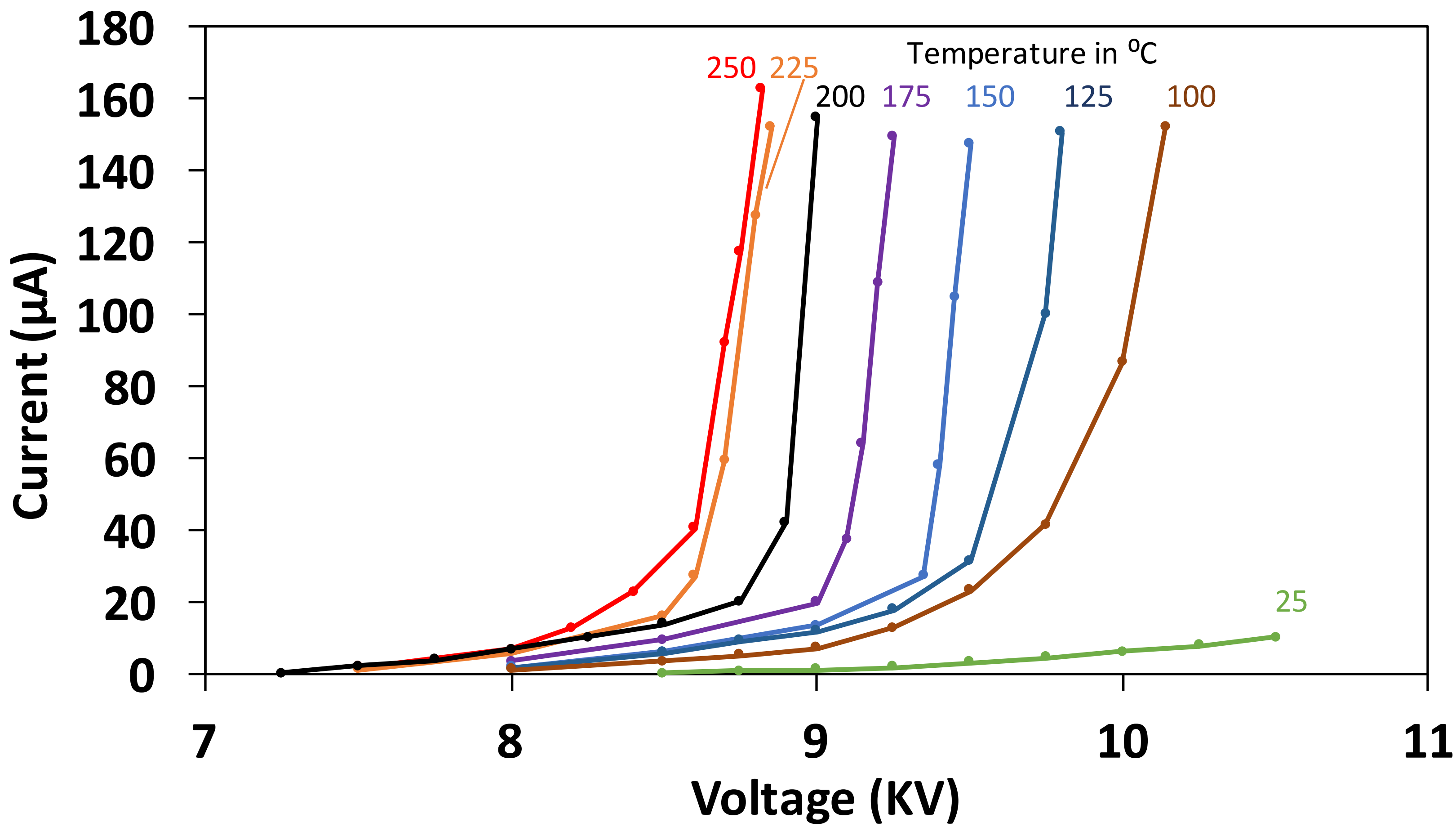
Conditioning of Sample



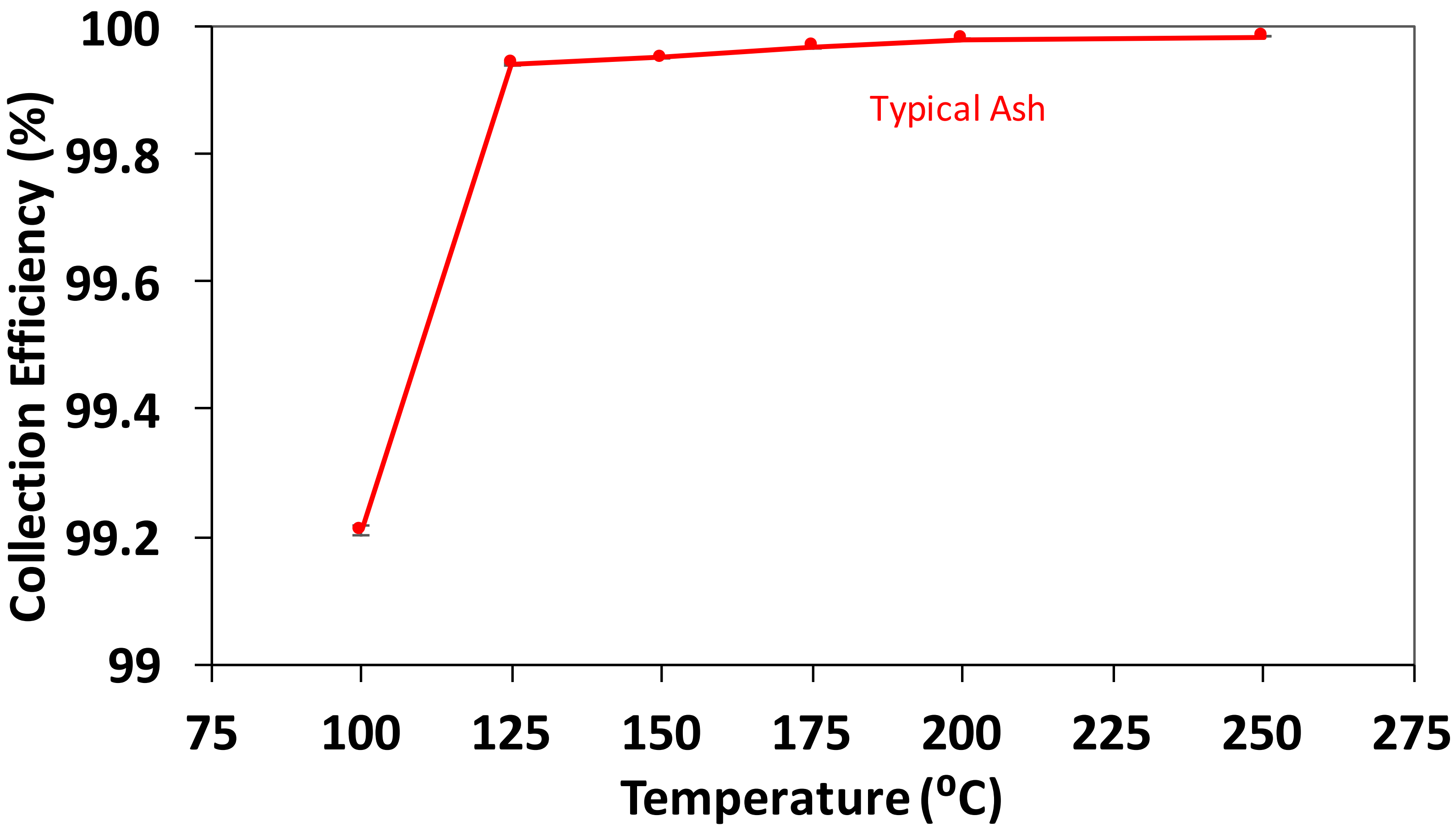
Chemical Composition

	% by weight					
	K	Na	Cl	SO_4	CO_3	Referred to in this presentation as
Low Carbonate Low Chloride	7	29	1	62	4	Typical Ash
High Carbonate Low Chloride	5	32	1	43	19	High Carbonate Ash
Low Carbonate High Chloride	3	32	12	50	3	High Chloride Ash

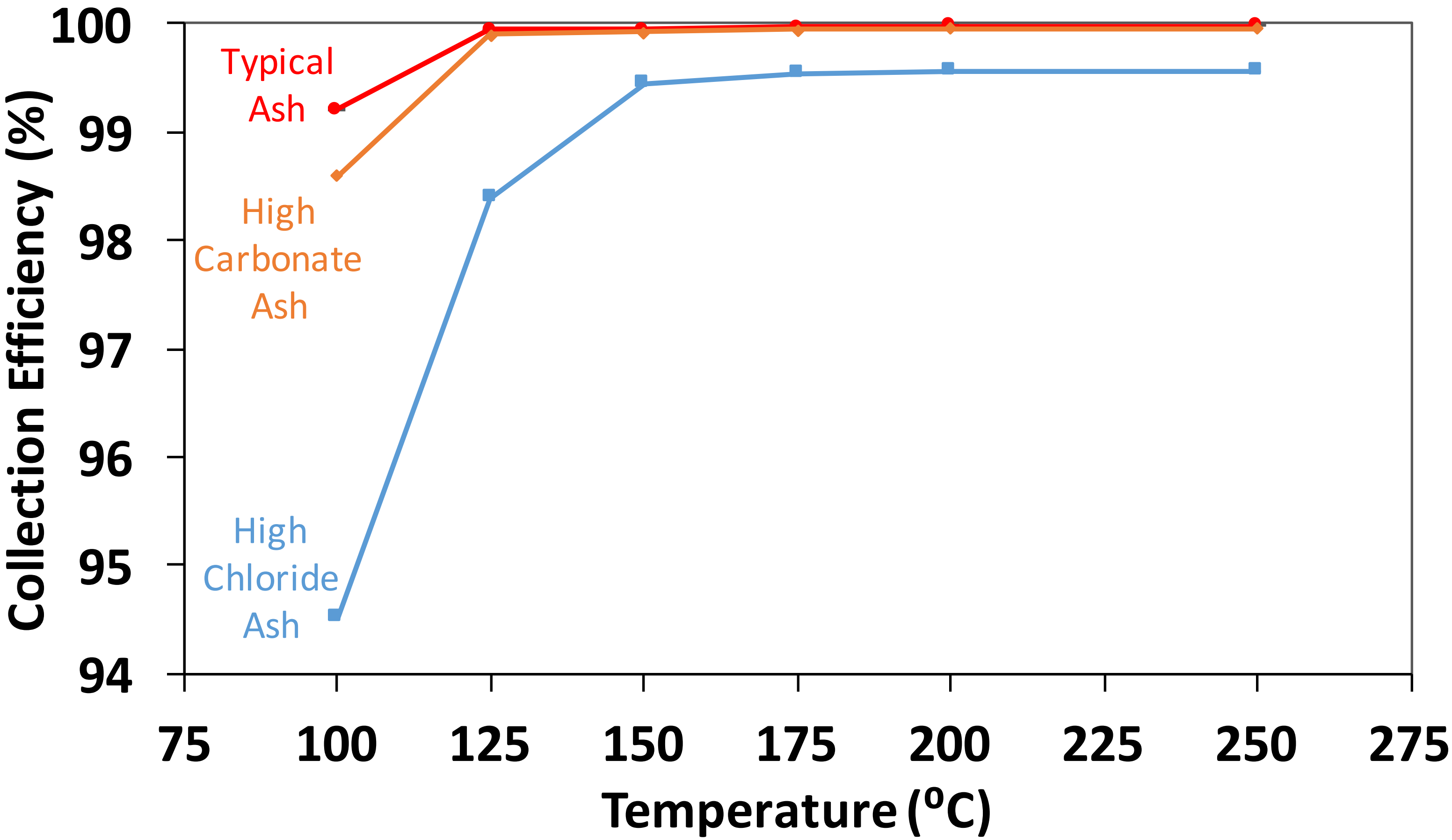
Effect of Temperature on ESP Current Voltage Curve



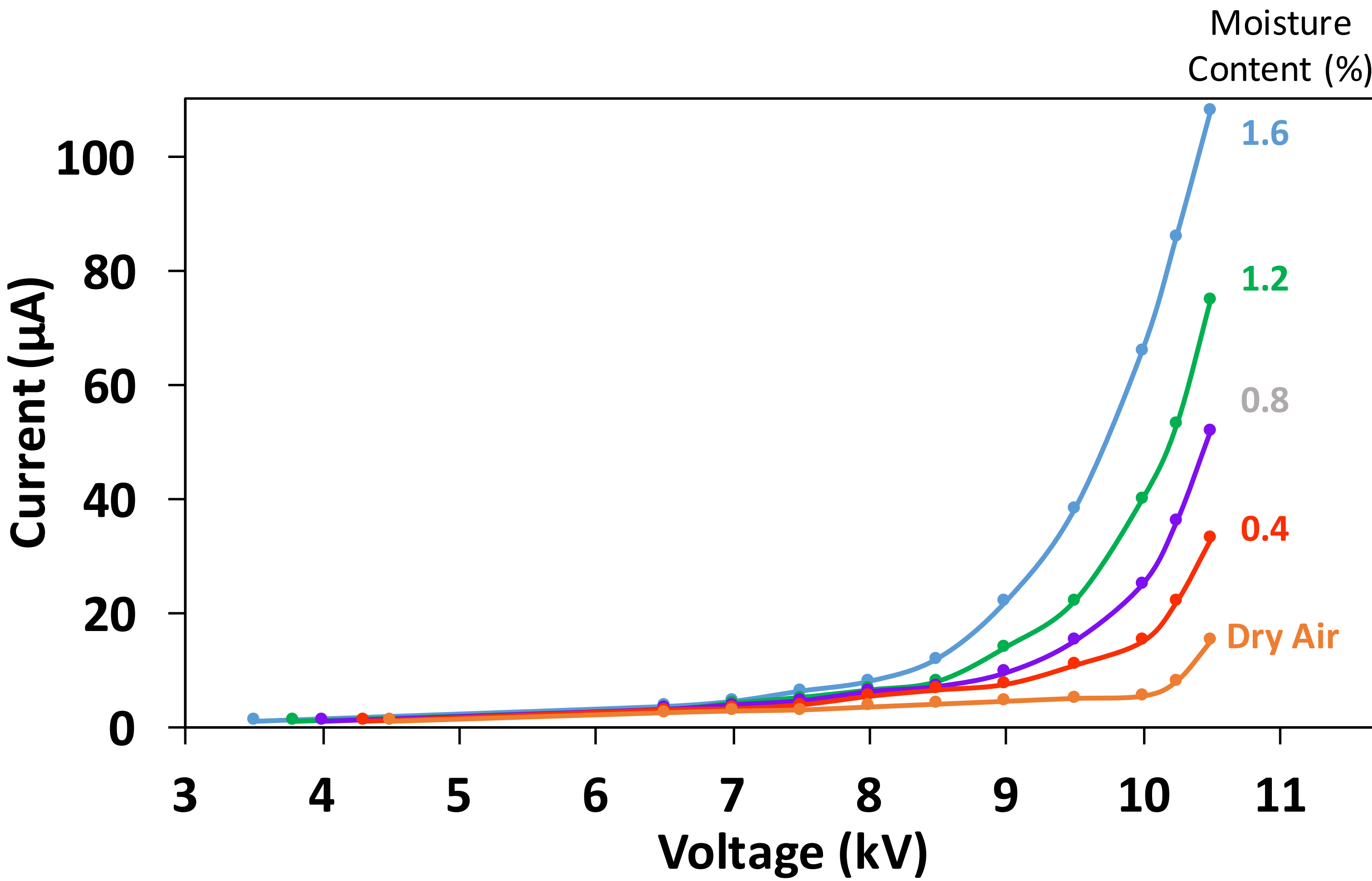
Effect of Temperature Collection Efficiency



Effect of Composition on Collection Efficiency

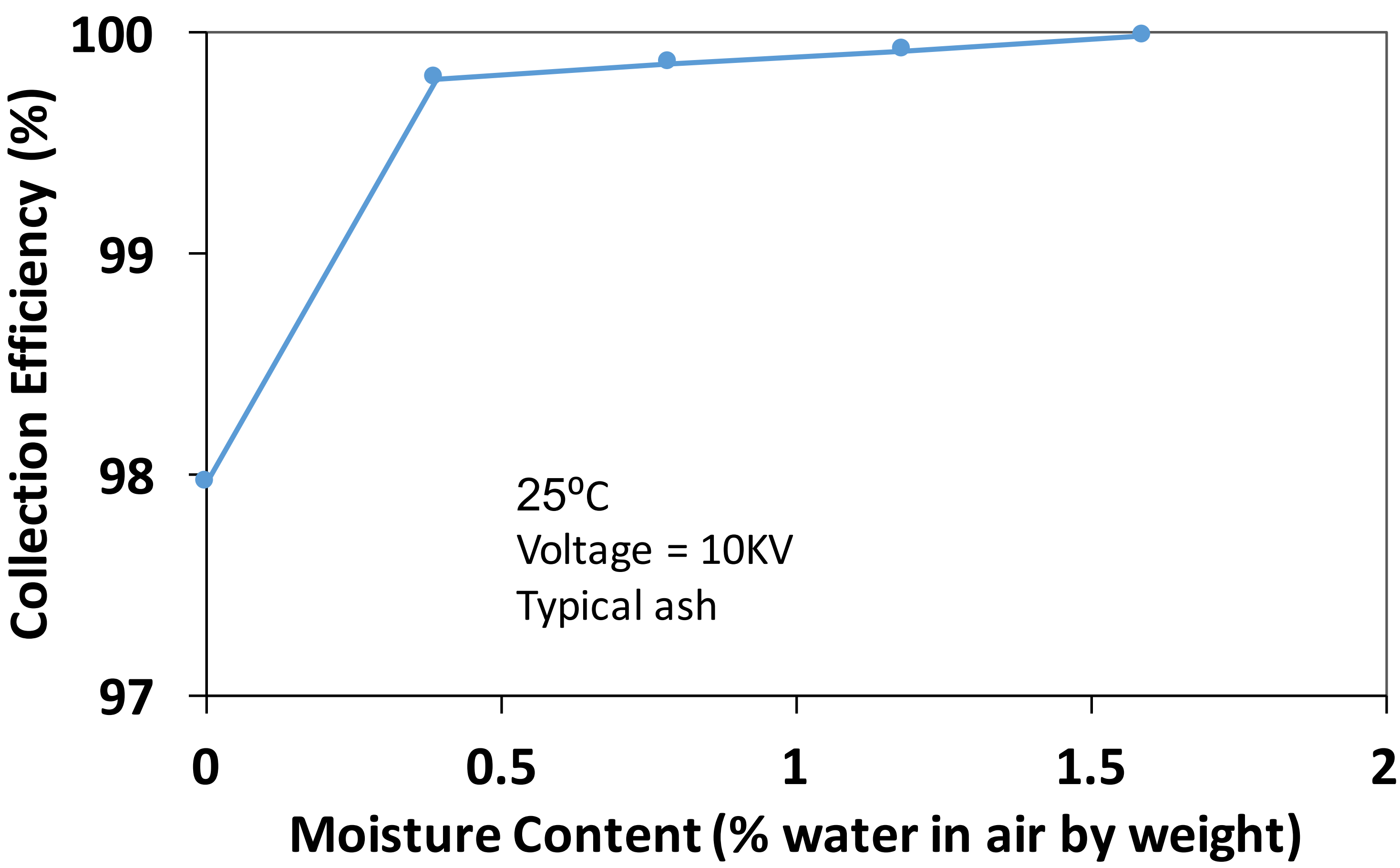


Moisture Content Results



Done at 25°C

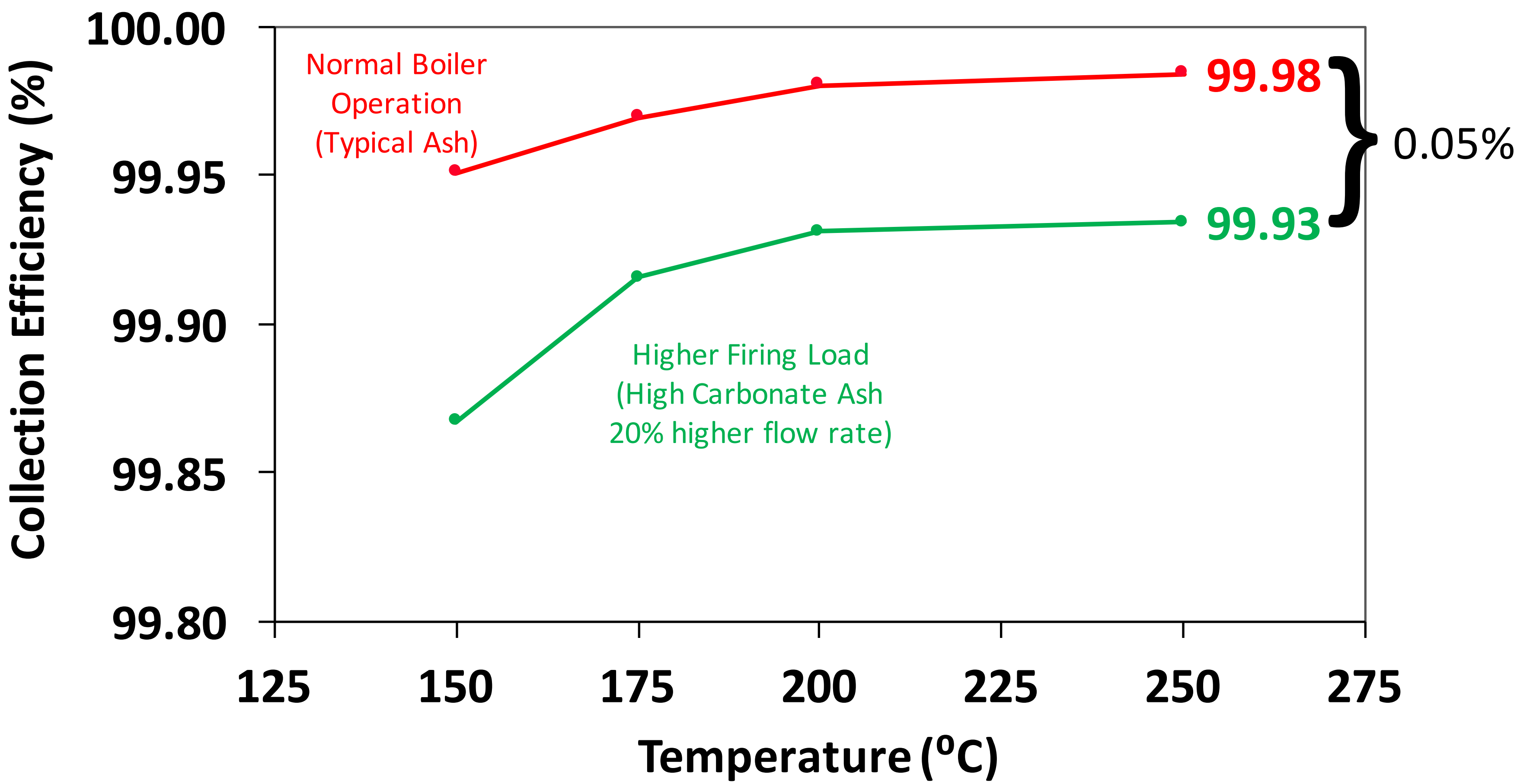
Effect of Moisture Content on Efficiency



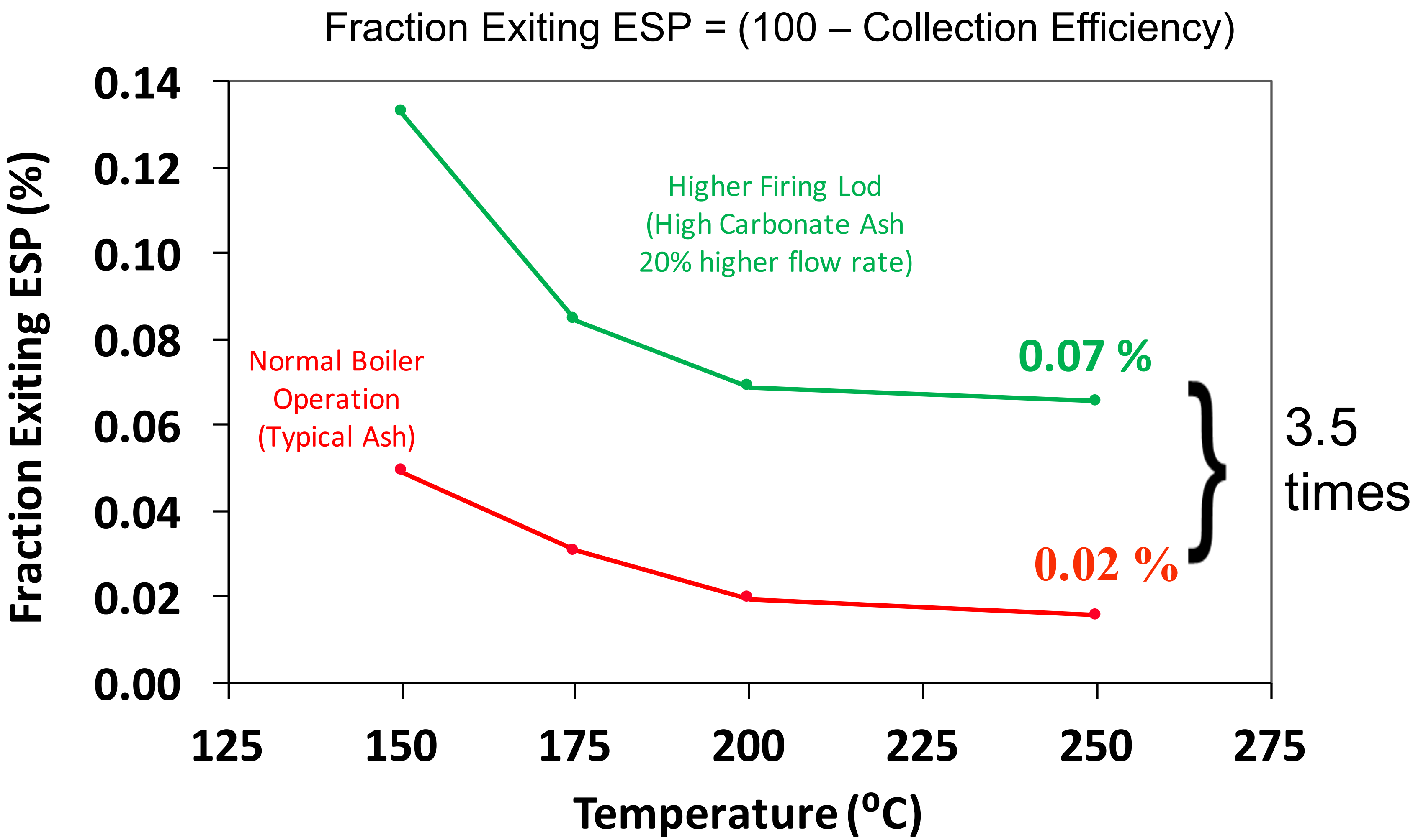
Relevance of Results to Industrial Application

- **Increasing firing load**
  - More black liquor burned to keep up with process
  - Requires higher combustion air volume
  - Leads to higher temperature in boiler bed
  - Higher carbonate content
- **Comparison with resistivity results**

Effect of Increasing Firing Load on Efficiency

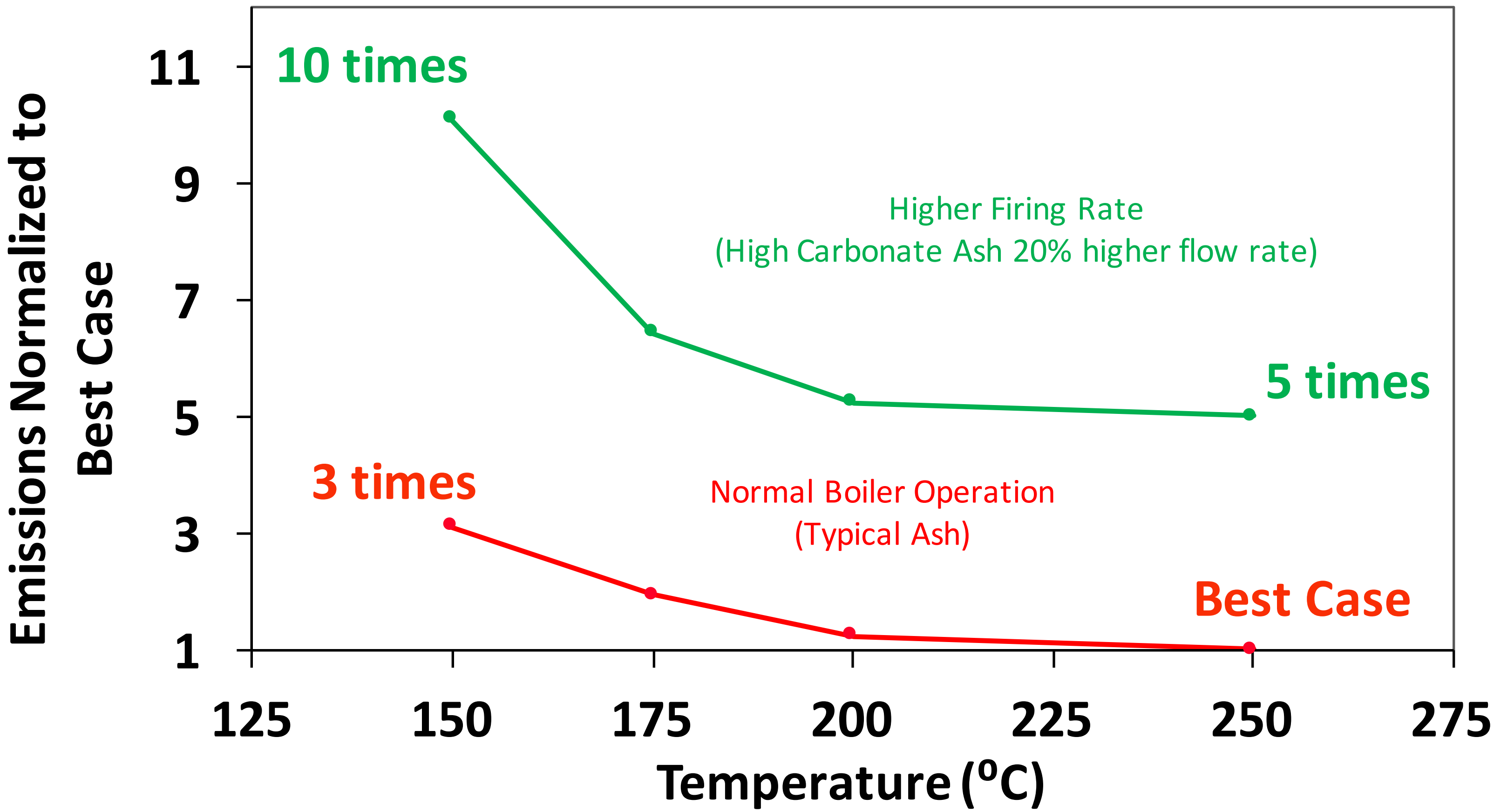


Fraction of Mass Exiting ESP at Higher Firing Load



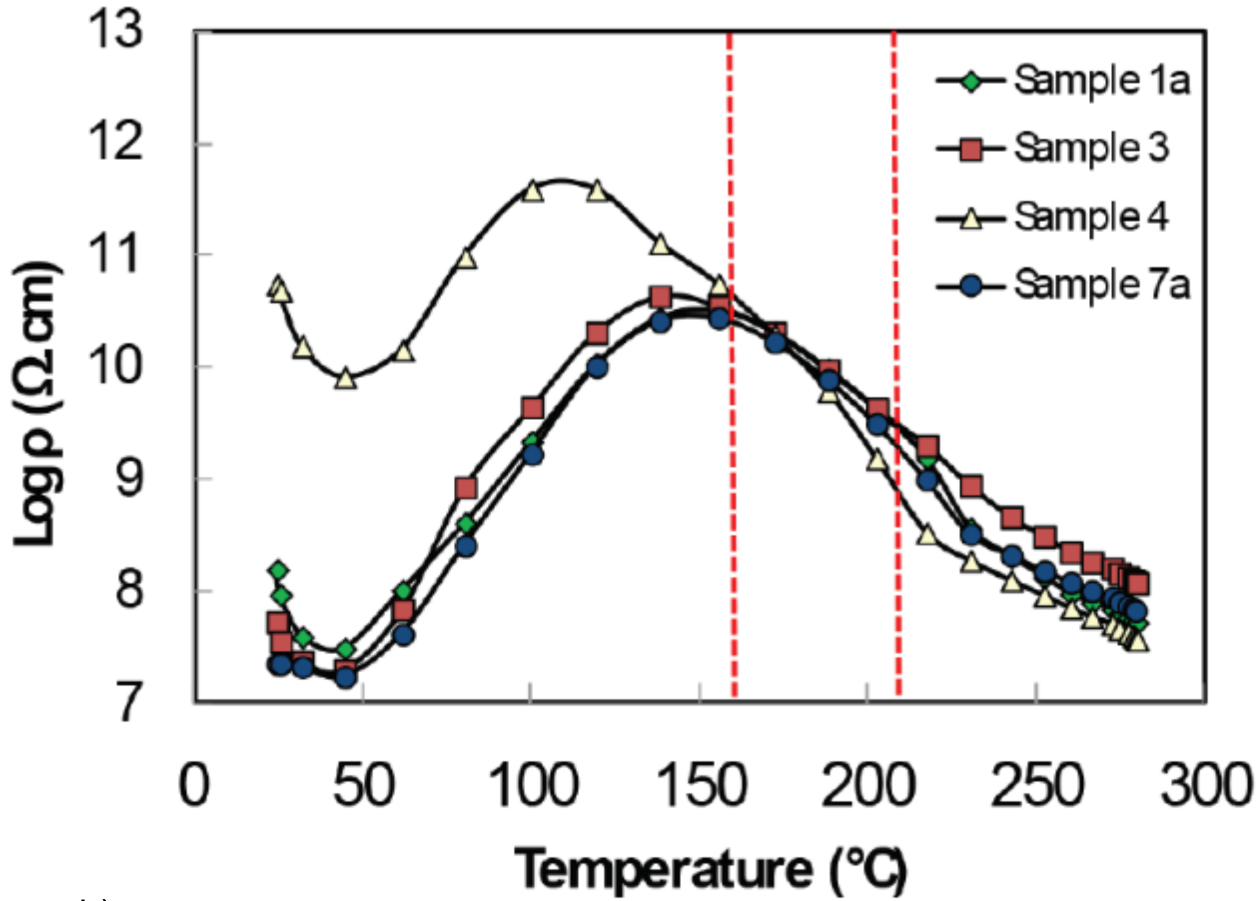
Effect of Increasing Black Liquor flow on Emissions

- **When accounting for flowrate difference, emissions increase even more**



Resistivity With Temperature

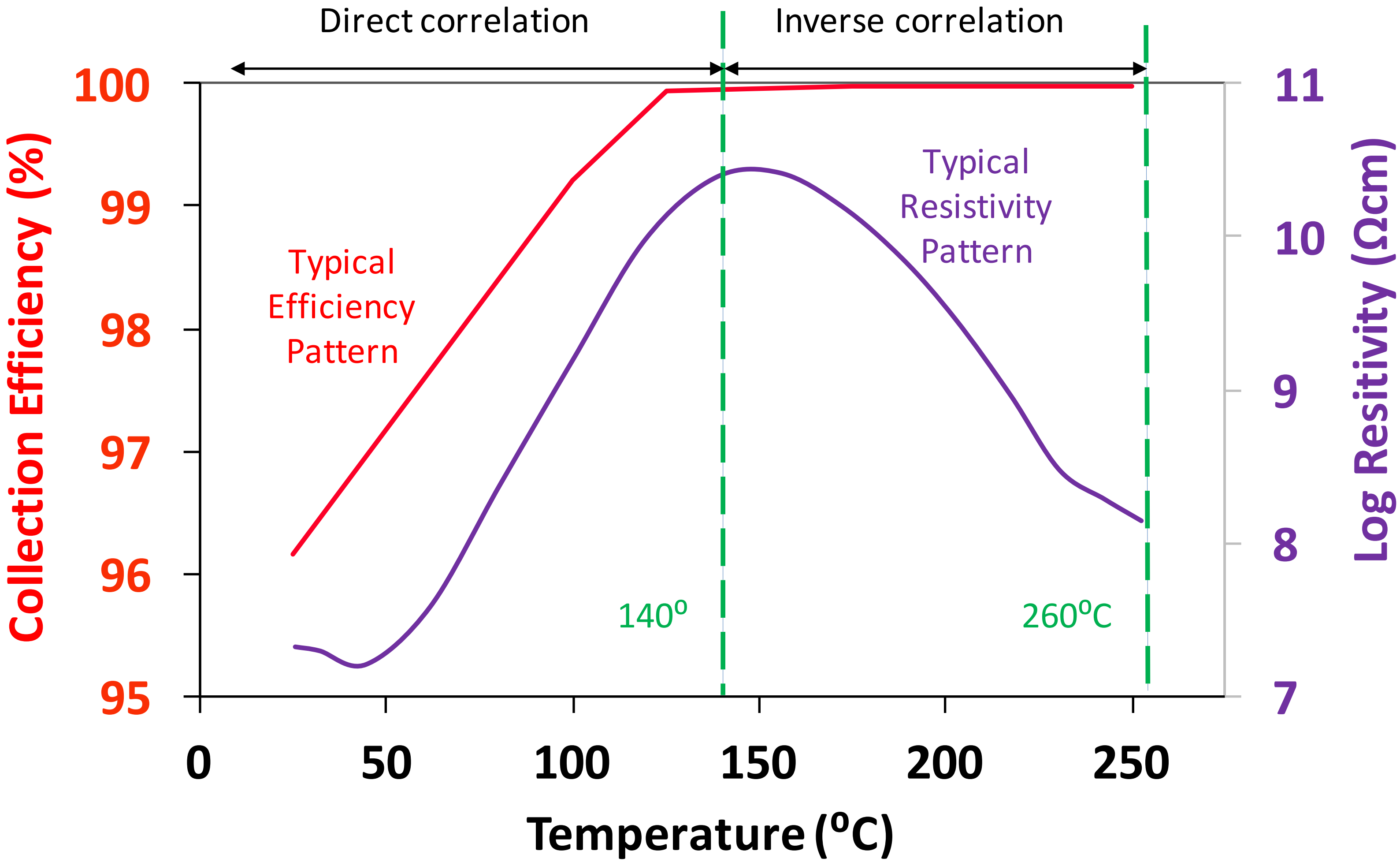
- From experience, higher efficiency associated with lower resistivity.



Sretenovic 2014
(resistivity of recovery boiler ash)

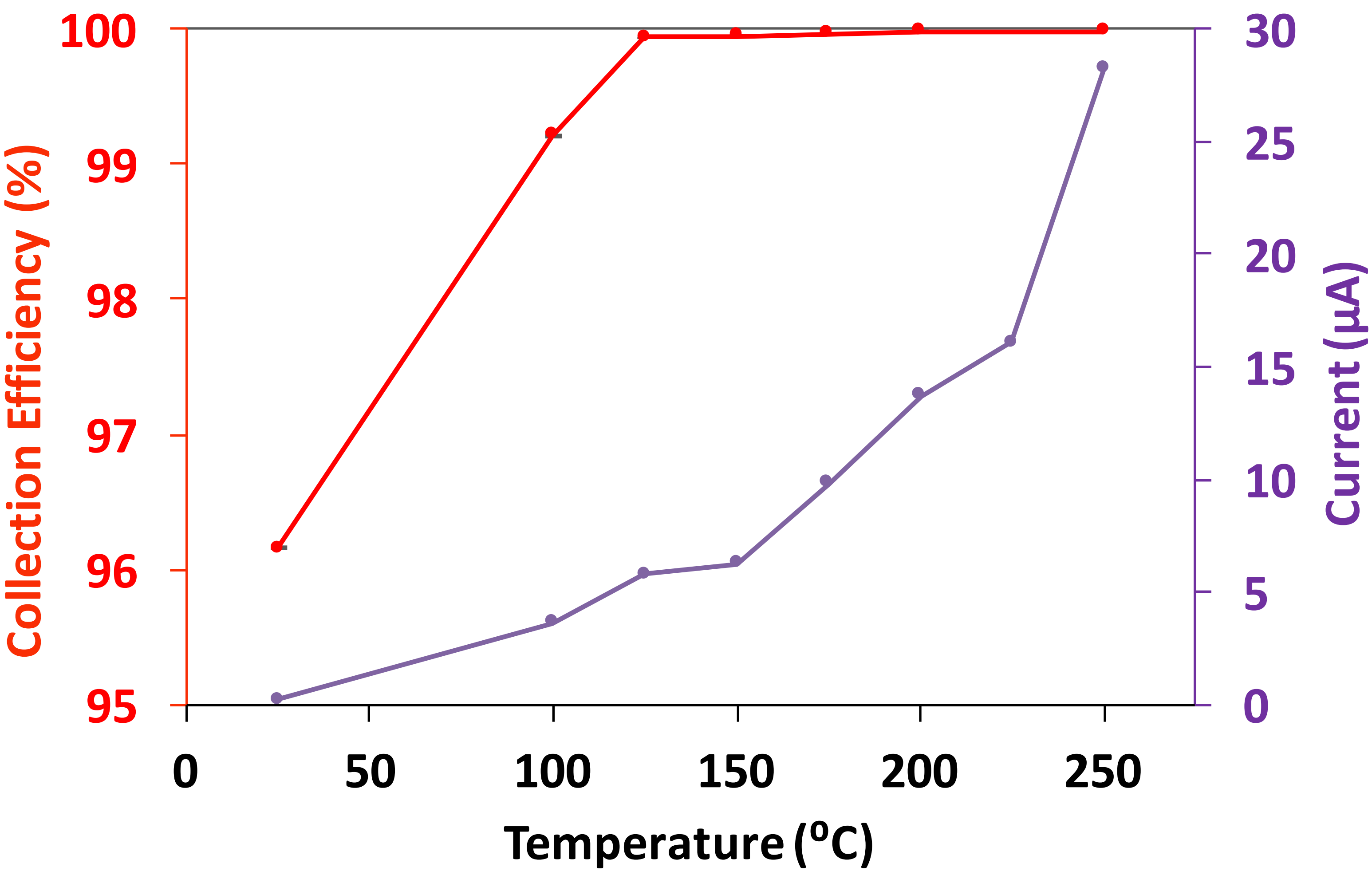
Efficiency and Resistivity Correlation

- Correlation changes with temperature



Efficiency and ESP Current

- Efficiency correlates better with current



Conclusion

- **Effect of composition:**
  - Low Carbonate, low chloride ash highest efficiency
  - High chloride lowest efficiency
- **Effect of Temperature:**
  - Collection efficiency increases with temperature
- **Effect of moisture content:**
  - Collection efficiency increases with increasing moisture content
- **Increasing firing load leads to significant increase in emissions (up to 10 times)**
- **Resistivity is not the only factor affecting efficiency**

Thank You