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Using EMSIM for Evaluating Pre-treatment and Smelting Options

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Agenda

- Context and purpose
- Mass and energy balance models
- EMSIM
- Technologies for pre-treatment and smelting
- Process models
- Simulation results
- Conclusion

Context

Opportunities and Challenges

- Commodity prices
- Rising energy cost
- Depletion of resources
- Lower-grade ores
- Raw material variability
- New process technologies
- Environmental pressure

Decision Making

- Respond effectively in existing operations
- Be proactive in new operations

Mass and energy balances, a critically important tool

Purpose

Introduce the EMSIM M&EB modelling approach

Demonstrate an application to ferrochrome production:

Reducing electrical energy consumption

Mass and Energy Balances

Theoretical Basis

For all elements *e*:

$$\sum \dot{m}_{e,products} = \sum \dot{m}_{e,reactants}$$

For all compounds *c*:

$$\sum \dot{m}_{c,products} + \sum r_{c,consumed} = \sum \dot{m}_{c,reactants} + \sum r_{c,produced}$$

For enthalpy:

$$\Delta \dot{H}_{required} = \sum \dot{H}_{products} + \dot{H}_{losses} - \sum \dot{H}_{reactants}$$

Mass and Energy Balances

Input Data

- Stoichiometry data
- Thermochemical data

  $\Delta H_{f,298}$, $S_{f,298}$, Cp(T), pure substances, **solutions**
- Raw material assays

  Chemical vs mineralogical
- Model parameters

  Equipment, operation, process

Mass and Energy Balances
Tools

General Purpose

- C/C++, Fortran
- Visual Basic
- MATLAB
- Python
- Microsoft Excel

Purpose-made Tools

- Metsim
- Pyrosim
- auxi (Python toolkit)
- EMSIM

Mass and Energy Balances
Model Types

Forward-calculating Models

- Typical operational inputs specified (assays, rates, ratios)
- Estimate outputs
- More fundamental
- Used for new processes/materials

Reverse-calculating Models

- Process performance specified (recoveries, C and S content)
- Estimate inputs
- More empirical
- Use as an operating tool in existing plants

EMSIM deals with both

EMSIM

A web-based tool for mass and energy balance modelling

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EMSIM

Core Principles

- High-quality thermochemical data
- Powerful thermochemical calculations
- Reduce mundane tasks
- Clear communication
- Flexibility
- Accessibility
- Security

EMSIM

Coals, Anthracites, Cokes, etc.

- Often treated incorrectly in energy balance
- EMSIM deals with this automatically
- Calculate $\Delta H_{f,298}$ for DAF coal from (DAF = dry ash free)
  - Ultimate assay
  - Gross calorific value

EMSIM

Coals, Anthracites, Cokes, etc.

Proximate Analysis	% Inherent moisture content	*(air-dried)*	1.9
	% Ash content	*(air-dried)*	16.4
	% Ash content	*(dry basis)*	16.7
	% Volatile Matter	*(air-dried)*	9.4
	% Volatile Matter	*(dry basis)*	9.6
	% Fixed carbon (calculation)	*(air-dried)*	72.3
	% Total sulphur	*(air-dried)*	0.80
	Gross Calorific Value *(as determined on an air-dried basis)*	*(MJ/kg)*	28.88
	% Phosphorus in Coal		0.012
Ultimate Analysis	% Carbon Content	*(air-dried)*	73.81
	% Hydrogen Content	*(air-dried)*	2.95
	% Nitrogen Content	*(air-dried)*	1.62
	% Oxygen Content (calculation)	*(air-dried)*	2.51
Forms of Sulphur	% Pyritical sulphur	*(air-dried)*	0.21
	% Sulfate sulphur	*(air-dried)*	0.02
	% Organic sulphur	*(air-dried)*	0.57

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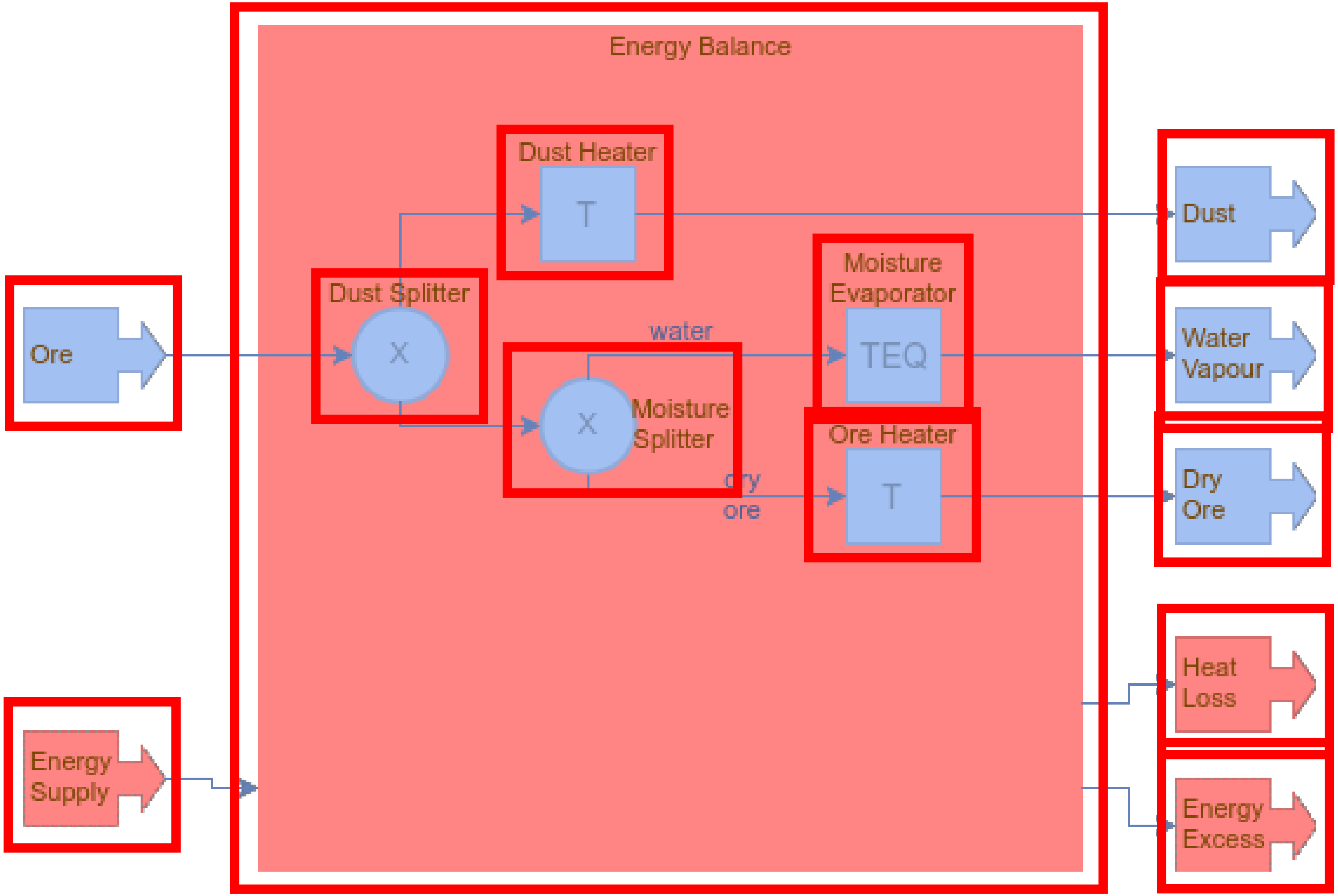
EMSIM

Switch to browser

EMSIM

Flow Sheet Example



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Process Technologies

Smelting

- Submerged-arc furnace (SAF)
- Direct-current furnace (DCF)
- Brush-arc furnace (BAF) (from GLPS)

Pre-treatment

- ~~Agglomeration~~
- Drying
- Pre-heating
- Pre-reduction

GLPS
PROJECT MANAGEMENT
ENGINEERING SERVICES

Process Models

- Drying and pre-heating
  (one model, different parameters)
- Pre-reduction
- SAF, DCF, BAF smelting furnaces
  (one model, different parameters)

Process Models

Switch to browser

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Simulation Work

Options Evaluated

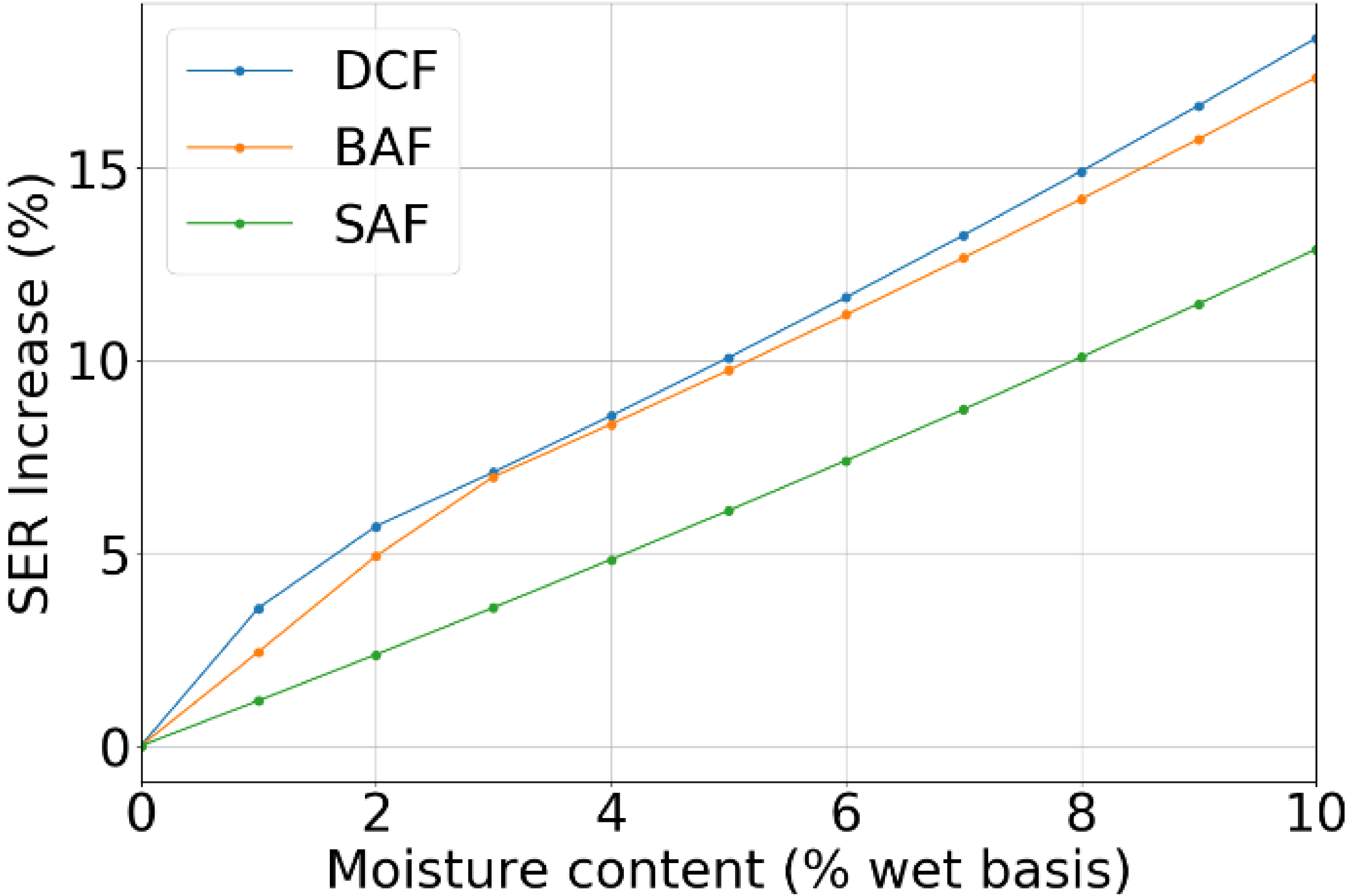
- Drying
- Pre-heating
- Pre-reduction
- Different furnaces

Parameters Considered

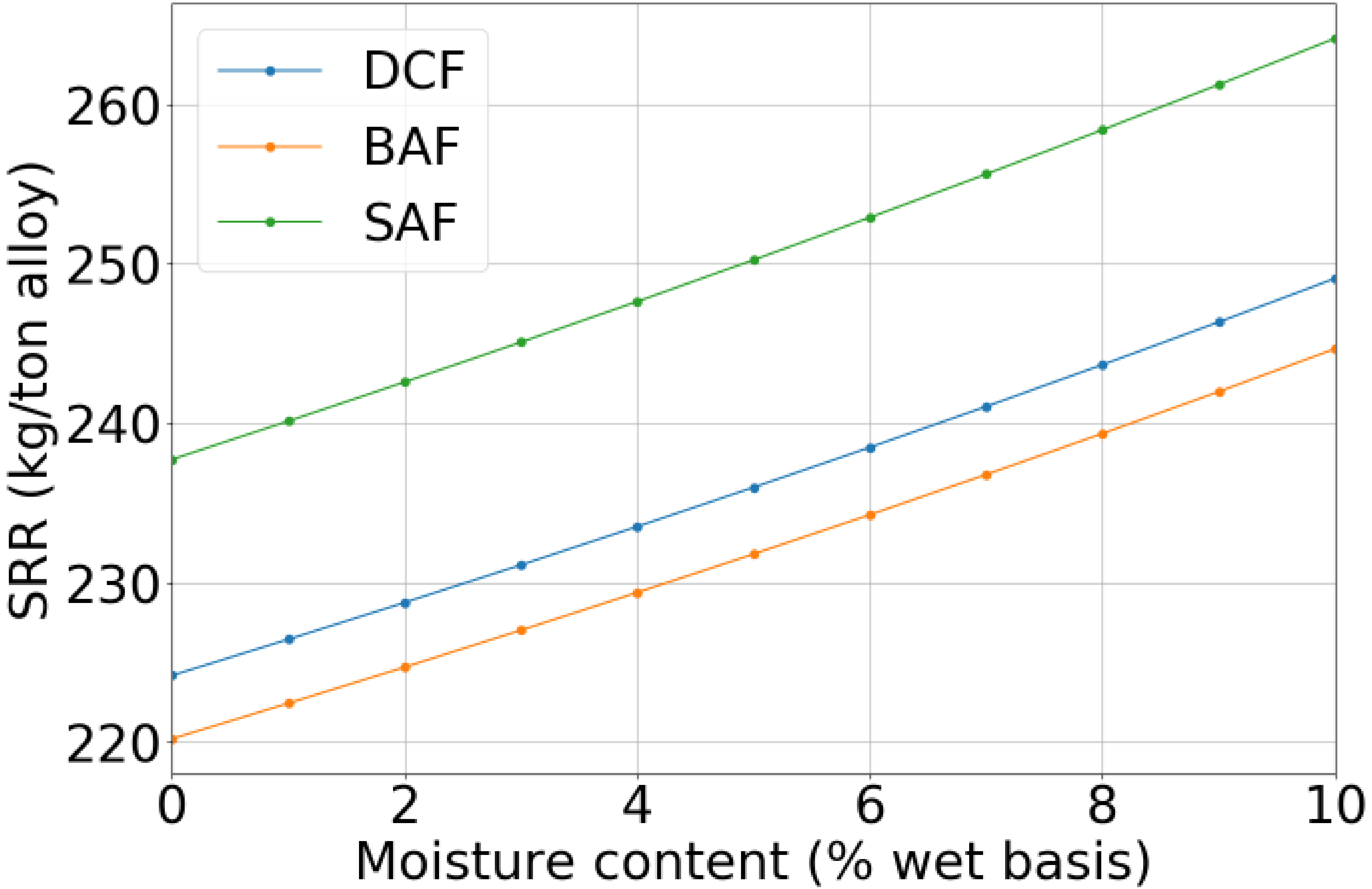
- Specific energy requirement (SER)
- Specific reductant requirement (SRR)
- Gas production

Simulation Results

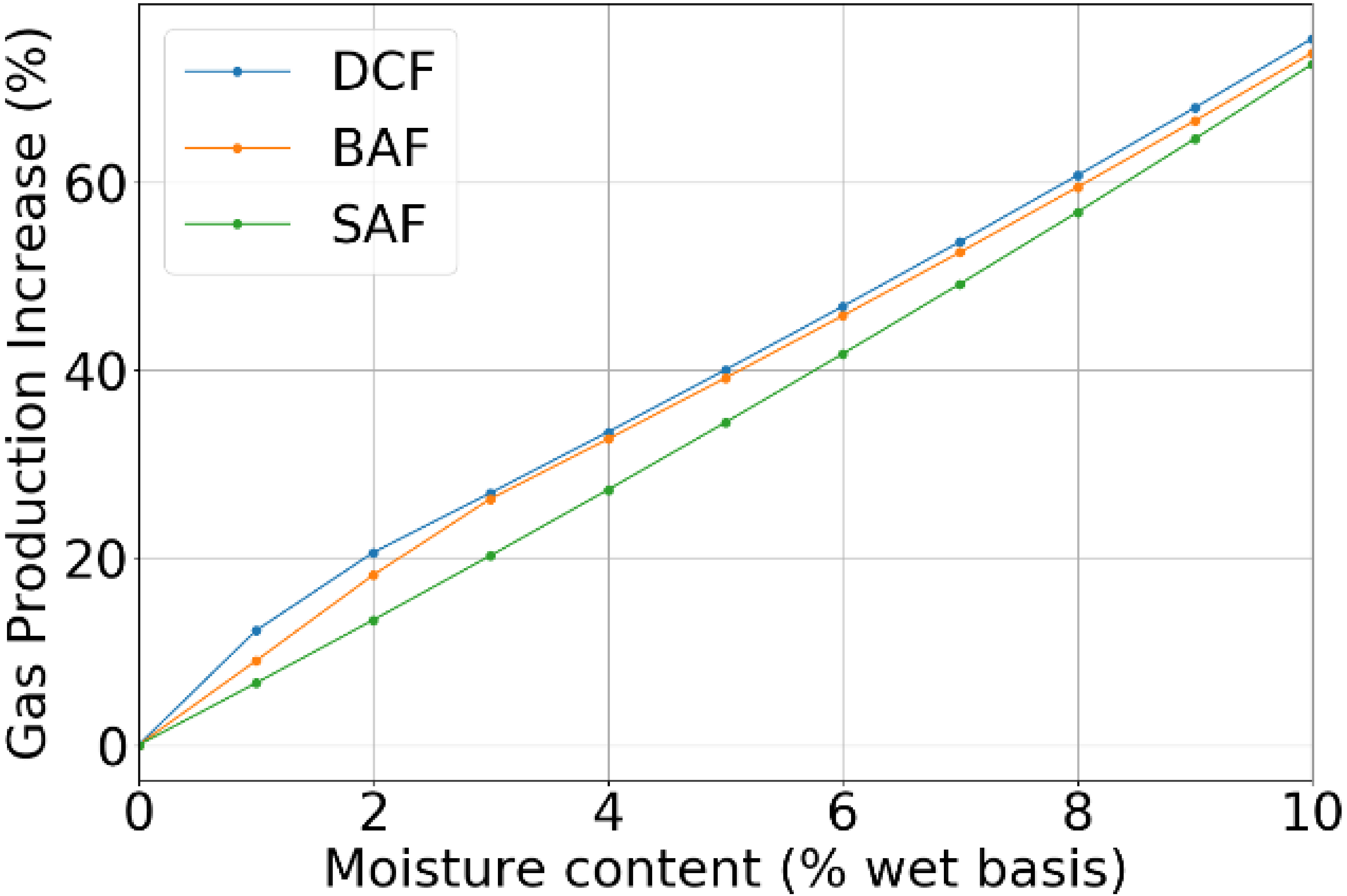
Influence of Moisture



DCF
BAF
SAF
SER Increase (%)
0
5
10
15
0
2
4
6
8
10
Moisture content (% wet basis)

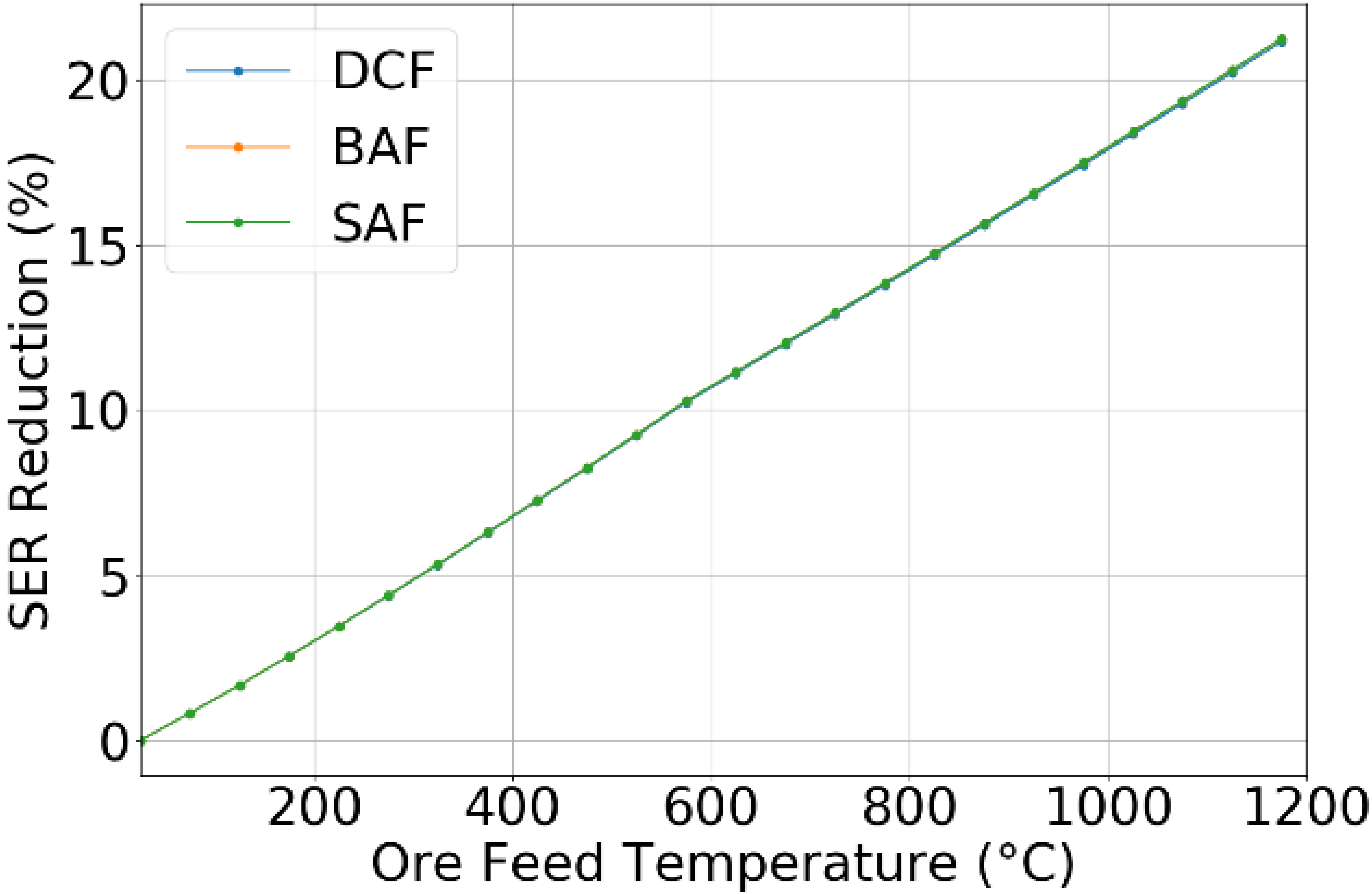


DCF
BAF
SAF
SRR (kg/ton alloy)
220
230
240
250
260
0
2
4
6
8
10
Moisture content (% wet basis)


DCF
BAF
SAF
Gas Production Increase (%)
0
20
40
60
0
2
4
6
8
10
Moisture content (% wet basis)

Simulation Results

Influence of Pre-heating


DCF
BAF
SAF
SER Reduction (%)
Ore Feed Temperature (°C)
0
5
10
15
20
200
400
600
800
1000
1200

Conclusions

Process Study

- Drying is beneficial

  Reduces energy and reduction requirement, and gas volume

- Preheating

  Between 15 and 20% reduction in electrical energy

- Pre-reduction
  - Largest reduction in electrical energy
  - Also largest capital and complexity

Conclusions

EMSIM Benefits

- Rapid model creation
- Focus on process
- Easily shared between users via web
- Models are solid foundation for
  - Improving understanding
  - Better decision making

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Thank you

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