ALBERTA INNOVATES

CLIMATE CHANGE INNOVATION AND TECHNOLOGY FRAMEWORK

Awardee Summary

CCITF PROGRAM	Clean Technology Development
PROJECT TITLE	Ongoing monitoring of steam quality with microwave technologies
SECTOR	Cleaner Oil and Gas, Energy Efficiency
ORGANIZATION	University of Calgary
PROJECT LEAD	Elise Fear
AI PROJECT ADVISOR	Vanessa White
GRANT AMOUNT	$50,000
START DATE	2018-10-01
END DATE	2019-09-27

PROJECT OBJECTIVE: A feasibility study to determine the specific sensing requirements, sensor designs and algorithms for steam quality monitoring with microwaves, and a to develop a lab-based prototype system to verify the findings.

PROJECT PROFILE: Steam is an essential part of SAGD, which involves producing steam, transporting the steam to well-heads and injecting the steam underground such that the heat transferred to the formation increases the viscosity of the oil. Steam quality, measured by the percentage of steam that is vapour, provides an indication of the amount of liquid present. In once-through steam generators (OTSGs), maximizing steam quality enhances energy efficiency and reduces waste water. With reduced steam quality at the wellhead for injection, less heat is available for transfer, which requires increased steam to achieve heating targets.

Steam assessment involves measuring temperature and pressure, then determining the internal energy (enthalpy) via tables. Density is also a function of temperature and pressure, and heat flow can be obtained if the flow rate is known. However, the amount of liquid present must also be determined to properly assess steam quality. Approaches to assessing steam quality include using a sampling tube attached to a calorimeter or obtaining a sample of steam and measuring conductivity once cooled. Both of these approaches require a stable flow in the pipes for accuracy. Additional techniques include determining mass flow rate with ultrasound, measuring absorbed light from laser sources and finding concentration by fitting to models, and estimating properties using changes in behaviour of resonant microwave cavities. However, there remains a need for continuous, fast and reliable measurement of steam quality that can be implemented at various locations from boiler to well-head. We aim to develop steam quality monitoring using microwave sensing techniques. The microwave frequency properties of air and water are significantly different. For example, the relative permittivity of a material describes electromagnetic energy storage. The relative permittivity of air and water are 1 and 80, respectively. Papers have previously suggest correlation between the microwave frequency properties of steam and steam quality. For steam quality assessment, a two-phase flow is likely to exist in the pipe. Therefore, microwaves have the potential to map the liquid

phase due to the significant permittivity compared to air and steam. This is achieved by integrating robust microwave sensors (antennas) into the pipe. By measuring reflected signals at each sensor, as well as signals transmitted between sensor pairs, the microwave frequency properties along various paths are estimated. By combining estimates along multiple paths, the two phases and associated estimated properties are mapped. Recent advances in measurements and algorithms are expected to provide fast, near real-time sensing of the two phases. The microwave antennas are low profile and incorporate robust materials (high temperature ceramics), so can be implemented at various locations in the system. In this project, we propose a feasibility study to determine the specific sensing requirements, sensor designs and algorithms for steam quality monitoring with microwaves. We also plan to develop a lab-based prototype system to verify our findings.

GHG EMISSION REDUCTION SUMMARY: