# Wind Farm Operation and Grid Integration

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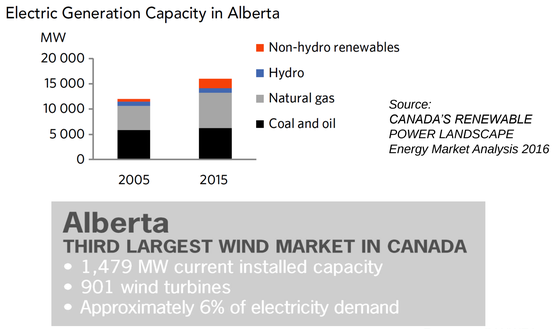
## BACKGROUND

- Increasing wind power development in Alberta will lead to significant challenges to the electrical grid in terms of:
  - ➢ Frequency control
  - ➢ Short circuit level
  - ➢ Interactions with surrounding systems such as High Voltage Direct Current systems (HVDCs)
- From wind farm's perspective, the Wind Turbine Generators (WTG) should work properly without early failure (on blades, gearboxes, generator bearings, power converters, etc.).
- For a large wind farm with hundreds of WTGs:
  - ➢ Operation and Maintenance (O&M) costs account for about 25% of the cost of wind power
  - ➢ Maintenance costs plus revenue loss due to downtime represents roughly 15% of the total cost of energy
- **<u>In general, this project focuses on</u>**:
  - ➢ Grid impact of 30% wind power in Alberta
  - ➢ Failure mechanism of key WTG components
  - ➢ Optimizing wind farm operation and maintenance

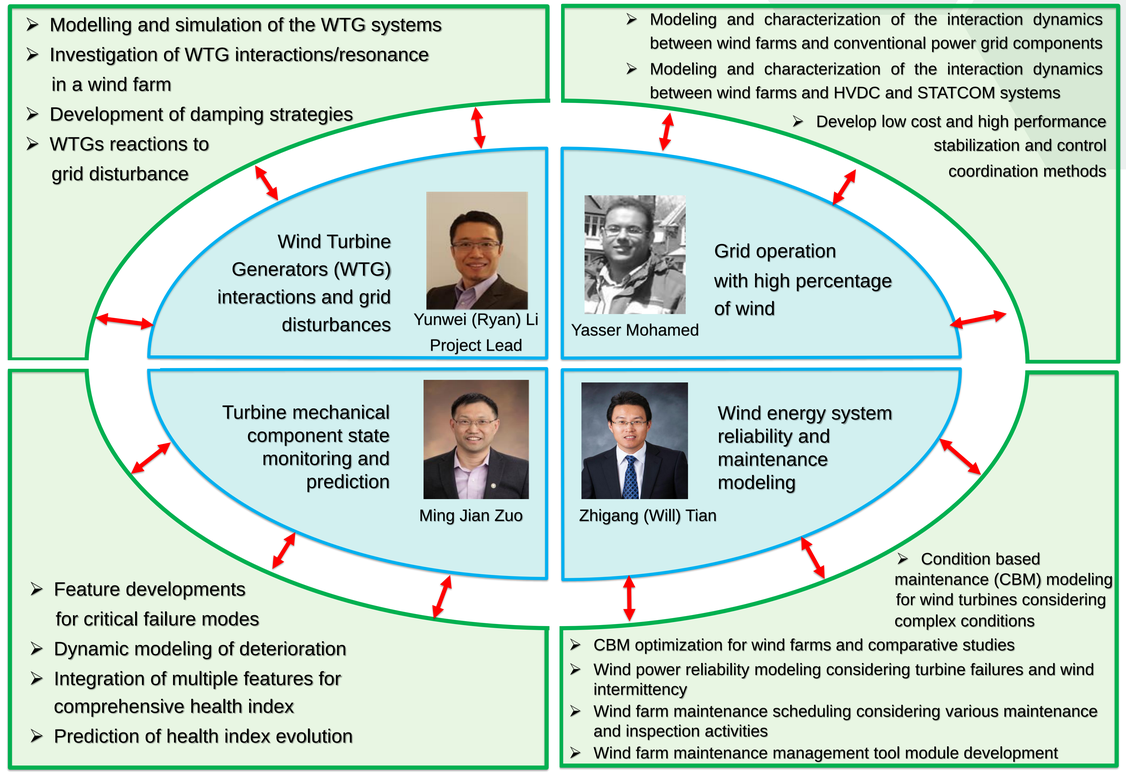



Resource: CANWEA

## SHORT-TERM OBJECTIVES

- Study the grid impact of 30% wind power in Alberta.
- Investigate the interaction of wind farm and the surrounding system with HVDC and Static Synchronous Compensator (STATCOM) and develop coordinated control scheme.
- Study the WTG interactions within a wind farm particularly under grid disturbance and develop damping approach.
- Study the failure mechanism of key WTG components.
- Development of WTG state monitoring and prognostics methods, and optimize wind farm operation and maintenance.

## PROJECT OVERVIEW




Collaboration with Other Teams:

- Collaborate with team in other projects in wind theme, including using the wind resource model and measurement data and evaluate the O&M cost and economic losses due to system failure
- Contribute to the evaluation of wind power availability and subsequently the reliability of microgrids.
- Collaborate with themes "Grids and Storage" particularly on using utility-scale and distributed storage for wind power regulation.
- Contribute to "System Wide" for analyzing and improving the reliability of all energy types and the whole energy system.

## THEME OVERVIEW

Wind

Wind has powered human societies for centuries, milling grain, pumping water, and driving ships around the globe. In recent years, maturing technologies have enabled the same resource to generate electricity, and contribute significantly to the energy needs of numerous countries. However, the challenges of harnessing wind remain: it is an ever-changing force, and its cycles often do not align with our demands. Effectively integrating wind into our grids and markets requires both technologies and an economic system that can accommodate these variations in supply. Understanding the special challenges of harnessing wind power in the Canadian north will be a specific priority.

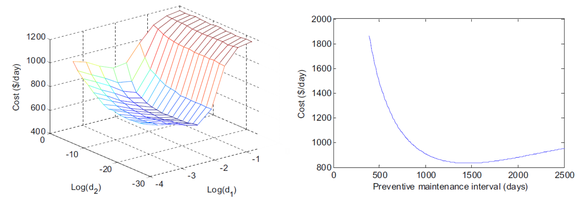
## EXPECTED OUTCOMES

***Anticipated Short-Term Outcomes of This Project:***

1) Developing new wind farm control and damping methods.
2) Design software tools for Operation and Maintenance (O&M).
3) Commercialization of developed control methods and Operation and Maintenance software tools with industry partners.

***Long-term Plans:***

1) Develop stronger connections with the wind power industry and utilities, and implement the development grid operation/control and wind farm maintenance strategies through field tests.
2) Establish a leading wind power research group at UAlberta, which will enable long-term competitive research in this area.




Cost comparison: condition-based maintenance vs preventive maintenance
(Source: Tian et al, *Renewable Energy*, 2011)

## EXTERNAL PARTNERS

External partners (existing or under development) of this project will add expertise and collaborate on:

- Wind power grid integration and grid reliability,
- WTG interaction and reliability study,
- Wind farm control and operation,
- Gearbox health monitoring,
- Wind farm operation and maintenance.

Partners include:

- National: AESO, University of Calgary
- International: Aalborg University (Denmark), University of Stavanger (Norway), Tsinghua University (China), Zhejiang University (China), University of Pretoria (South Africa), University of Sfax (Tunisia).

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