ALBERTA INNOVATES

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RENEWABLE AND ALTERNATIVE ENERGY

Blockchain-Based Smart Contracts in the Future Smart Grid

Albertan homeowners who install solar panels on their roof can use the power that they generate to reduce the power they require from their utility. If the solar panels are large enough to provide more power than they need in their own home, they can send the excess power back to the electricity grid. The homeowner will receive a credit on their electricity bill and carbon credits to trade. There is a problem, however, if hundreds of thousands of homeowners start selling excess power to the electricity grid and to each other, the existing grid and billing systems may not be able to keep up.

This project explored how the use of blockchains and smart contracts can be used to enable homeowners to actively participant in energy markets. This will enable the development of new markets and create a more flexible power grid that can meet the challenges of small, distributed energy producers coming online.

FUNDING DETAILS

RECIPIENT:
Dr. Scott Dick
University of Alberta

PARTNERS:
Canadian Foundation for Innovation, Future Energy Systems Research Institute

TOTAL BUDGET:
$2,464,206

AI FUNDING:
$132,629

PROJECT DATES:
Nov 2020 – Mar 2023

PROJECT TRL:
Start: 3
End: 4

APPLICATION

This program built on existing laboratory prototypes of microgrid power transactions to investigate how system-wide attributes (like voltage stability) can be enforced by an electric system operator when power flows between arbitrary customers. These blockchain-based smart contracts were designed to ensure stability - by coordinating voltage stability actions between customers using federated learning. The Electricity System Operator would then oversee the fulfillment and settlement of all such contracts using a block-chain based network.

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PROJECT GOALS

- Design smart contracts that consistently enforce voltage stability on the electricity grid.
- Extend that design to include the participation of Battery Energy Storage Systems in ensuring voltage stability.
- Extend the contract design to enable and support a distributed voltage and reactive power optimization algorithm to maximize power being delivered to the grid.
- Validate all three of the above contracts through simulations in the Future Smart Grid Technology Lab at the University of Alberta.

BENEFITS TO ALBERTA

- Reduced GHG emissions as solar power displaces daytime fossil-fuel power generation.
- Improved electrical power reliability in locations served only by distributed- and micro-generation.
- Increasing the amount and value of carbon credits awarded to consumers and homeowners.

5 Publications

7 Students Trained

Enabler of Future GHG Reductions

CURRENT STATUS

December 2024

The project was completed in March 2024 and the Final Public Report is available. Hyperledger blockchain was used. Federated machine learning algorithms were used to generate smart contract properties, affording privacy protection for households. IoT technologies were found useful for inferring voltage instability. Residential battery energy storage system (BESS) draw/send power ability can support voltage optimization based on an Australian data set with high market penetration. Due to loss of partner for the carbon offset aspect, the project focused on power aspects of smart contracts.