Storm Response Crew Planning Optimization

Junziqi Shao | Mohamed Baiumy | Tianlang Ryan Zhao | Xuanbo Lambert Liu

NOVA SCOTIA POWER — An Emera Company

DALHOUSIE UNIVERSITY — FACULTY OF ENGINEERING — Department of Industrial Engineering

Problem Background

Nova Scotia Power Inc. (NSP) is committed to anticipate the effects of future storm systems and offer precise restoration times to customers across the province by planning for both pre-storm and in-storm scenario planning activities.

● Pre-Storm Planning

The Scenario Planning tool is a program developed to help prepare for storms that estimate the restoration timelines of 95% to 100% of the customers and staging crews throughout the province using up to 4 scenarios generated by the weather damage prediction model. Teams from NSP manually assign crews to all municipalities and counties in NS, without the ability to easily distinguish between dayshifts, nightshifts, and external crew members.

● In-Storm Planning

As the storm hits the province, the In-Storm Planning tool was manually tweaked to provide the "best" next-day crew allocation plans using the current outage volume and available resources while prioritizing >1000 customers affected outage events.

Objectives

● Pre-Storm Planning

Develop a new Scenario Planning model that optimize the allocations of day, night, and external crews across the territories and counties, and calculate precise estimated restoration times for customers across the province.

● In-Storm Planning

NSP prioritizes vulnerable areas (those with > 1000 affected customers) and commits to reflect that in the model. As such, Develop a new model that supports decisions regarding restoration priorities and real-time outages routing for crews. Routing distances aim to be minimal.

Methods

● Operation Research Linear Programming

Minimized maximum absolute difference between
1) duration of restoration, AND 2) outage per crew ratio,
to provide the optimal crew allocation solutions with consideration of client crew allocation preferences using Excel VBA & OpenSolver.
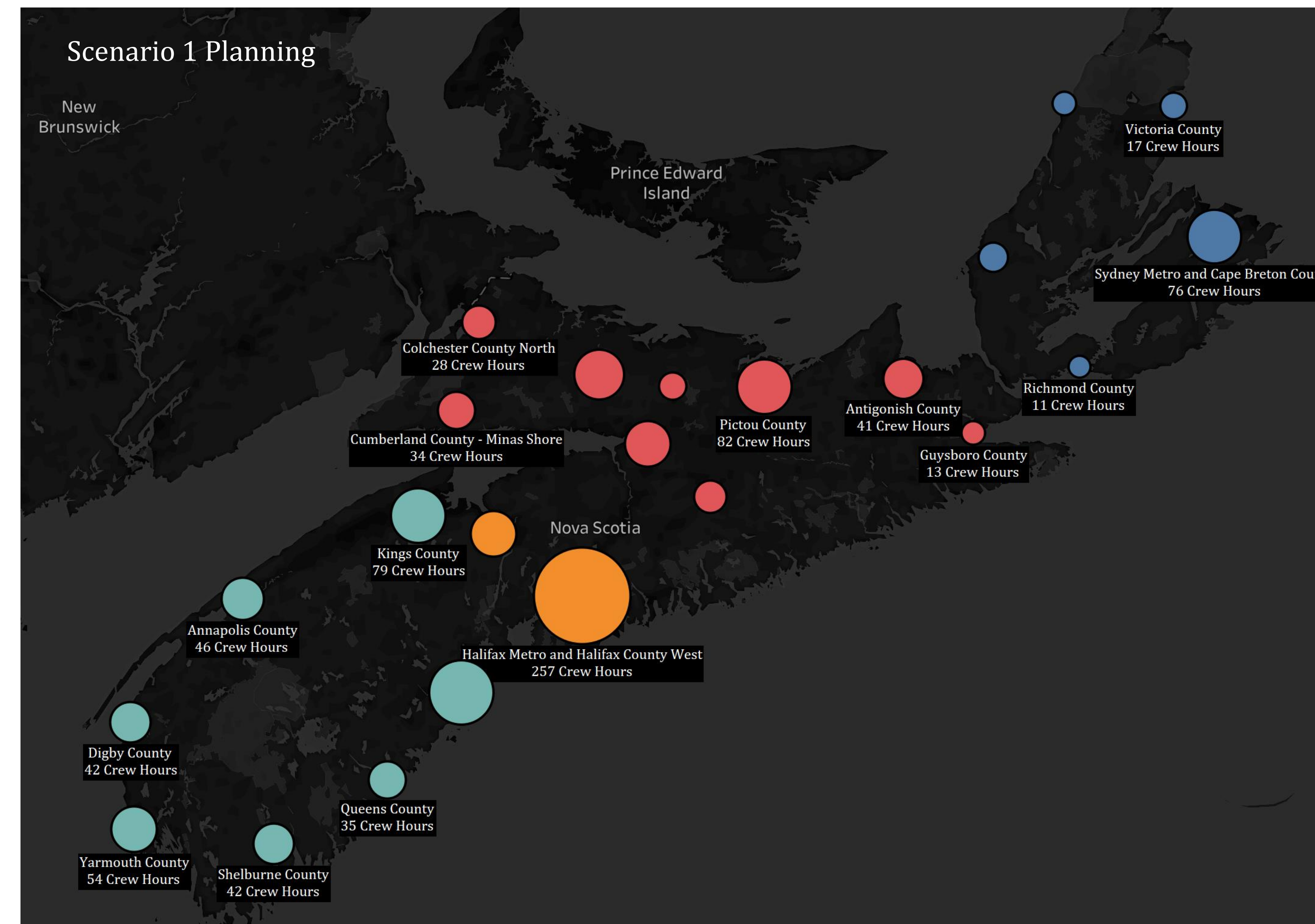
● Minimum Cost Network Flow

Based on real-time outage events and damage assessments, minimized the total crew traveling distance with respect to real-life constraints. The model was developed in Excel using OpenSolver.

● Data Visualization

Built sustainable data connections between Tableau & Excel that enabled live data extraction, transformation and loading (ETL). Executed the Scenario Planning dashboard by using parameter drilldowns & data clustering on Tableau.

Results

Scenario 1 Planning

New Brunswick — Prince Edward Island — Nova Scotia

- Victoria County 17 Crew Hours
- Sydney Metro and Cape Breton County 76 Crew Hours
- Colchester County North 28 Crew Hours
- Richmond County 11 Crew Hours
- Antigonish County 41 Crew Hours
- Pictou County 82 Crew Hours
- Cumberland County - Minas Shore 34 Crew Hours
- Guysboro County 13 Crew Hours
- Kings County 79 Crew Hours
- Annapolis County 46 Crew Hours
- Halifax Metro and Halifax County West 257 Crew Hours
- Digby County 42 Crew Hours
- Queens County 35 Crew Hours
- Yarmouth County 54 Crew Hours
- Shelburne County 42 Crew Hours

- With the selection of a scenario, the dashboard dynamically displays crew allocation results with colours-coded territories. The size of circle signifies the forecasted weather severity of the counties.
- Users can see detailed information about crew allocation by hovering over each county.

	Start of Rest..	95% ETR	100% ETR
HRM DAR/HFX/SAC..	9/23/2020 6:00	9/23/2020 18:50	9/24/2020 2:22

- Day Crews: 8
- External Crews: 3
- Night Crews: 2 (4.3)

- Scenario Planning model outputs the exact number of day, night, and external crews to be allocated across the province in both region and county levels.

Territory	Day Crew	Night Crew	External Crew	ETR
Central	12	2	5	2020-09-23 14:52
East	5	6	14	2020-09-24 16:08
Northeast	26	1	0	2020-09-25 15:30
West	7	4	9	2020-09-26 15:27

- When the model is supplied with real-time outage information, it produces a travelling route for crews between regions. By finding the shortest travelling distance, the routing model will suggest the origin, destination, and number of crews that should be moved by the client, which is the optimal routing solution.

Territory	Origin (from)	Destination (to)	Internal Crew Moved	External Crew Moved
Central	BAY	DAR	2	6
Central	HFX	WIN	2	1
East	SAC	AMH	3	6
Northeast	SYD	ANT	2	5
Northeast	AMH	MAB	1	4
West	YAR	SHE	6	12

Storm Event Timeline

NSP aims to develop a comprehensive suite of tools and procedures for weather and damage prediction and storm response planning to improve the reliability for their customers continually.

Pre – Storm Planning
- Start
- Weather Forecast Model
- Damage Prediction Model
- Scenario Planning

Scenario Planning Outputs
- Scenario Planning
- Damage Prediction Model
- Weather Forecast Model
- Suggested Crew Allocation
- Estimated Time of Restoration

Storm Event
- Customer Communication
- Damage Assessment
- In-Storm Night Planning

Outage Restoration
- Crew Tracking
- Restoration Prioritization
- Crew Routing
- Customer Restoration
- Storm Reporting
- End

- High: >1000 Customer Affected
- Med: >100 Customer Affected
- Low: Rest of Customer
- Goal: Optimized Route of Travel