Model Description for the Phase 2 Hurricane Recovery Problem

Brian French

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1 Variable Glossary

1.1 Constants

- C_{FlowI} is steady state flow on the grid before the hurricane
- C_{lineIJ} is the capacity limit for the power line going from IJ
- $C_{RepairTimeI}$ is the time to repair node I
- $C_{TravelIJ}$ is the travel time between nodes I and J
- C_{broken} is a coefficient of "broken-ness" representing the average slowdown from debris on the road and minor flooding
- $C_{demandI}$ is the power demand at location I in the pre-disaster steady state
- $C_{GeneratorCapacityK}$ is the maximum power generation for generator K

1.2 Variables

- Z_i^t is the total power flow at node i at time t
- X_{ij}^t is the flow from i to j at time t
- G_k^t is the production from generator k at time t
- Y_i^t is 1 if node i is functioning at time t
- W_{ij}^t is 1 if line ij is functioning at time t
- S_i^t is 1 if node i is serviced at time t
- K_{ij}^t is 1 if node j follows node i in the tour at time t
- F_i^t is 1 is node i is serviced at time t t

1.3 Sets

- L is the set of nodes
- P is the set of power lines
- R is the set of roads
- T is the planning horizon
- J is the set of Generators

2 Model

$$Minimize \sum_{i \in L} \sum_{t \in T} C_{FlowI} - Z_i^t$$

Subject to:

(1) $Z_i^t = (\sum_{j \in L} X_{ji}^t) Y_i^t \ \forall t \in T \ \forall i \in L$

(2) $\sum_{i \in L} X_{ik} = \sum_{j \in L} X_{kj} + C_{demandK} \ \forall t \in T \ \forall k \in L$

(3) $\sum_{i \in L} C_{DemandI} Y_I^t = \sum_{k \in J} G_k^t \ \forall t \in T$

(4) $G_k^t \leq C_{GeneratorCapacityK} \ \forall t \in T \ \forall k \in J$

(5) $X_{ij}^t \leq C_{lineIJ} W_{ij}^t \ \forall t \in T \ \forall i, j \in P$

(6) $\sum_{i \in L} C_{RepairTimeI} F_i^t + \sum_{i \in L} \sum_{j < i \in L} K_{ij}^t C_{TravelIJ} C_{broken} \leq 8 \ \forall t \in T$

(7) $Y_i \leq \sum_{0}^{t} F_i^t$

(8) $\sum_{j \in L} K_{0j}^t \geq 1$

(9) $\sum_{j \in L} K_{ij}^t - \sum_{j \in L} K_{ji}^t = 0 \ \forall t \in T \ \forall i \in L$

(10) A subtour elimination constraint, though I'm not sure what the best way to set this up is

2.1 Explaination of Constraint Systems

- Constraint (1) defines total flow for inclusion in the objective function. This might be able to be dropped at a later date, but is currently included for ease of understanding/formulation until there's a working case.
- Constraint (2) defines flow balance equations for each node
- Constraint (3) defines input/output network balance. This is assuming Generator ramp time can be ignored, but that's fine since excess power can always be dropped to ground.
- Constraint (4) constrains power generation to be in the realm of feasible production
- Constraint (5) constrains line flow to be inside line capacity
- Constraint (6) constrains/decides what gets done during a shift

3 Comments

- I'm assuming that we're staying in the region of safe production for generators, a later thing to think about is "pushed" generators where they can be run in overdrive for short periods of time
- The first constraint system is not linear, and I'm worried about it causing a mess of runtime.
- Does the lack of multiplication by functionality in the second constraint system mean that we could choose X values that are non-zero for a broken node?