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Canadian Society for Civil Engineering

Optimizing Environmental Sustainability and Public Benefits of Transportation Network Programs

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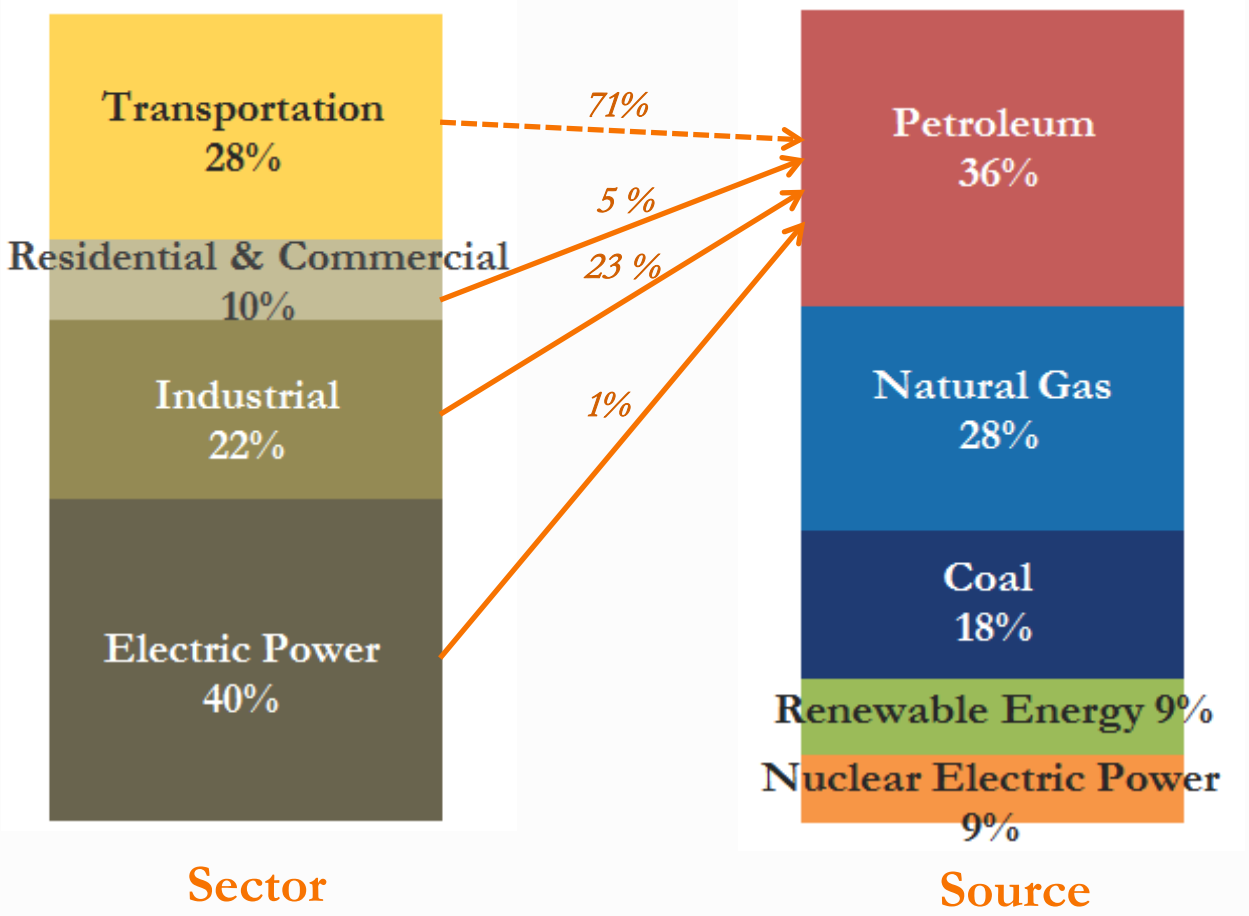
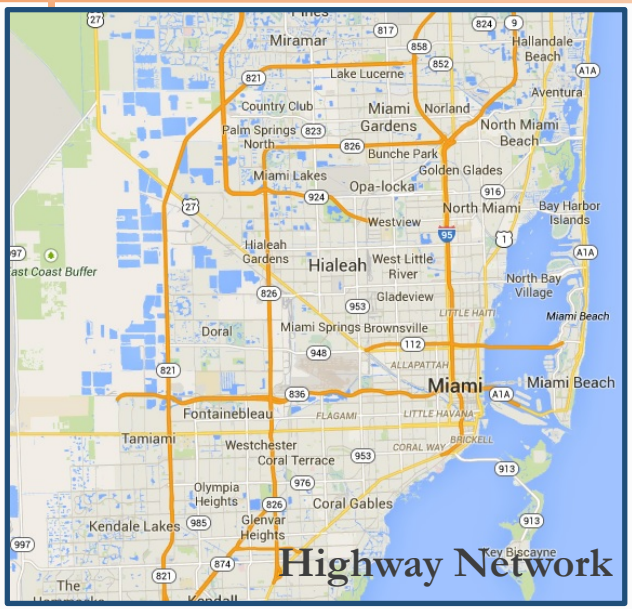
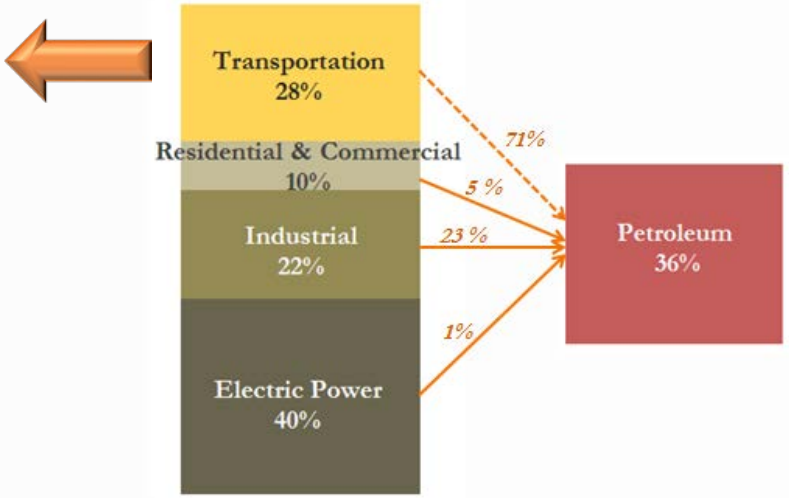
Introduction



Introduction





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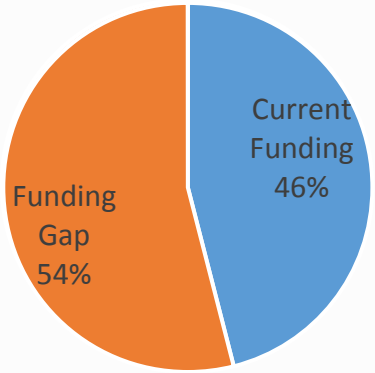
Roads Grade



2013 ASCE Infrastructure Report Card

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Introduction

Examples of Current Funding Allocation Practices

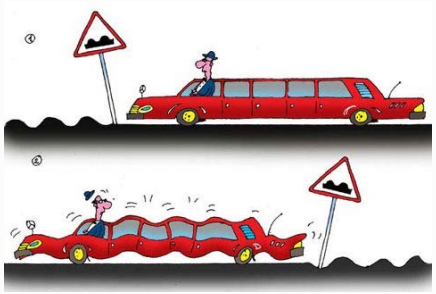
Traffic Congestions

Pavement Conditions

What about Energy Performance of Rehabilitation Plans?

Can the current practice be improved?

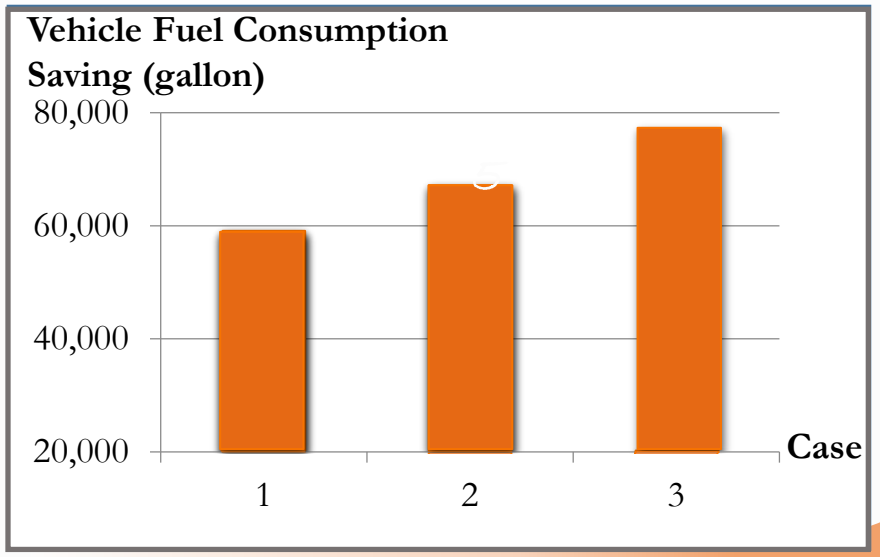
Case 1: Traffic Volume



Case 2: Pavement Conditions

Case 3 : Fuel Consumption

Road Section	Traffic Volume (vehicle/day)	Pavement Roughness (m/km)	Length (km)
1	49,000	4.5	8.0
2	20,000	3	3.2
3	30,000	3.5	4.0
4	25,000	4.5	2.4
5	37,000	5	5.6
6	55,000	3.5	8.0
7	45,000	2	6.4
8	63,000	2	4.8
9	13,000	5	4.8
10	75,000	3	3.2



Background

Optimization in Highway Rehabilitation

Single-Objective Optimization

Chan et al. 1994 – minimize cost
Ferreira et al. 2002 – minimize cost
Wang and Lui 1997 – maximize overall network performance

Multi-Objective Optimization

Zhang et al. 2012 – energy consumption + GHG emissions + construction costs
Mathew and Issac 2013 – minimize construction cost + maximize pavement performance
Orabi and El-Rayes 2011 – maximize net benefits + minimize network service disruption
Lidicker et al. 2012 – minimize construction costs and GHG emissions

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Research Questions

- What is the impact of decision making in highway rehabilitation efforts on total network fuel consumption and the expected public benefits?
- How can the total fuel consumption and expected public benefits for the entire network can be modeled?
- How can rehabilitation decisions be optimized in order to maximize public benefits and minimize energy consumption under budget constraints?

Research Objectives

- **Model** — Fuel consumption in transportation networks
- **Estimate** — Cost of travel delays due to highway construction operations
- **Estimate** — Expected savings in road user costs due to completed rehabilitation projects
- **Analyze** — Public costs and benefits of highway rehabilitation efforts over time
- **Optimize** — Limited funding allocation to rehabilitation projects

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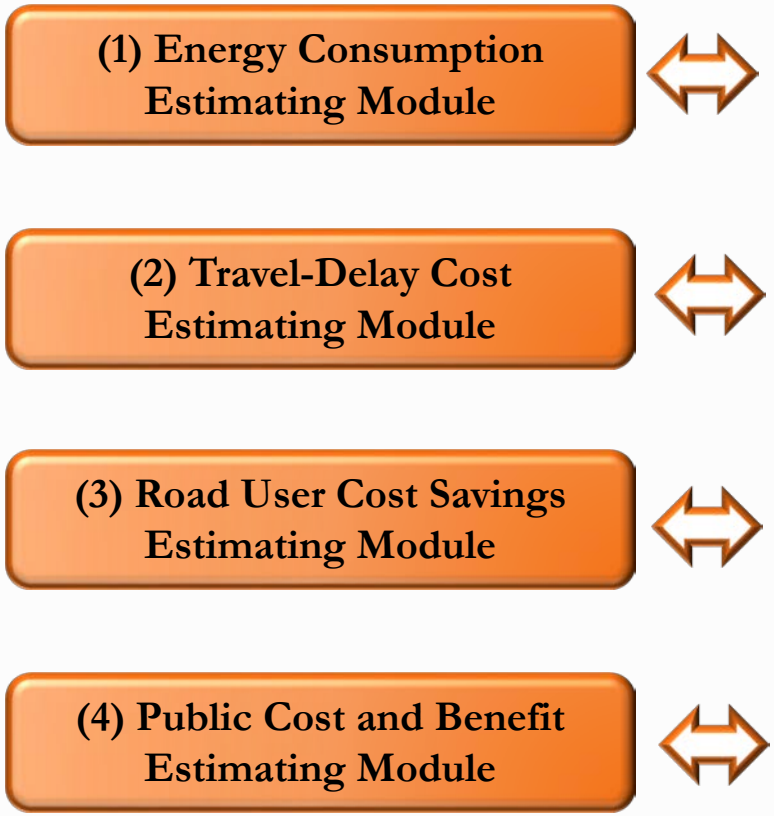
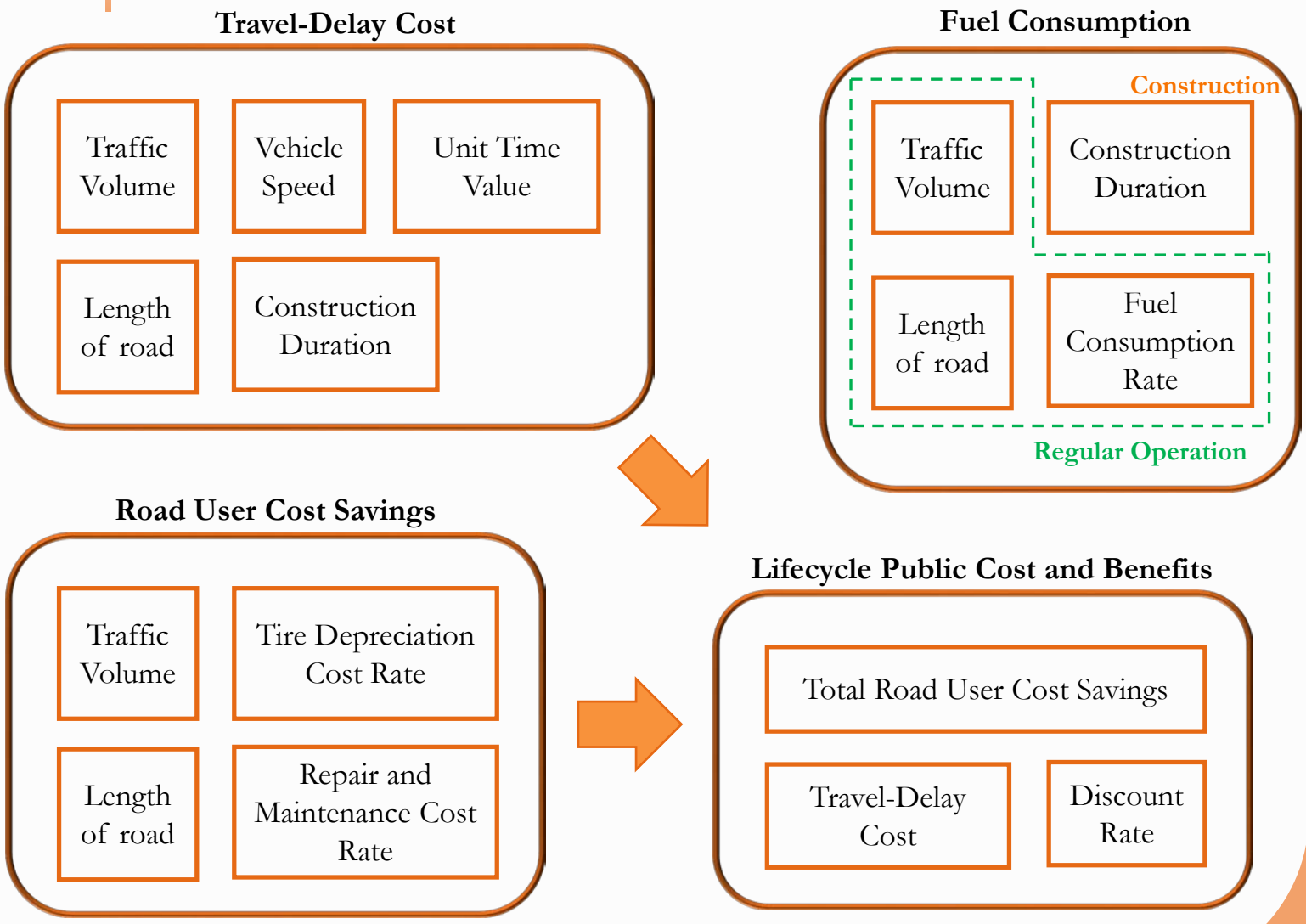
Multi-Objective Optimization Problem



Methodology



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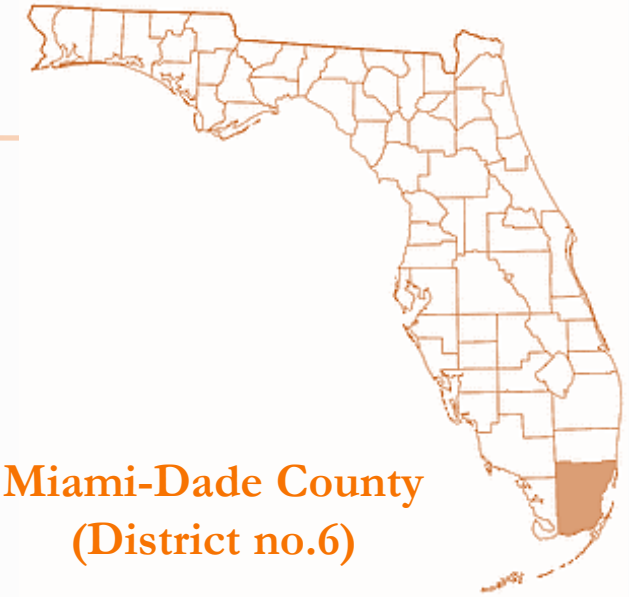
Application Example



Miami-Dade County (District no.6)

Project	IRI (m/km)	Traffic volume (veh/day)	Length (mile)	Free-flow speed (mph)	Work zone speed (mph)	Construction cost (million dollars)	Duration (week)	Number of lane	Total ESAL (million ESAL/lane)
1	4.50	45,500	2.87	40	25	9.17	46	4	0.3546
2	3.20	55,000	2.11	40	25	5.07	26	3	0.5715
3	2.80	37,500	4.05	40	25	6.48	33	2	0.5845
4	3.00	50,500	2.00	45	30	4.8	25	3	0.5247
5	4.00	35,000	2.04	35	20	3.26	17	2	0.5455
6	4.00	48,500	1.62	40	25	3.88	20	3	0.5039
7	3.80	33,500	1.69	45	30	4.06	21	3	0.3481
8	5.00	63,000	2.66	45	30	6.38	32	3	0.6546
9	4.00	13,000	1.74	40	25	1.39	7	1	0.4052
10	3.80	71,000	2.24	45	30	5.37	27	3	0.7377

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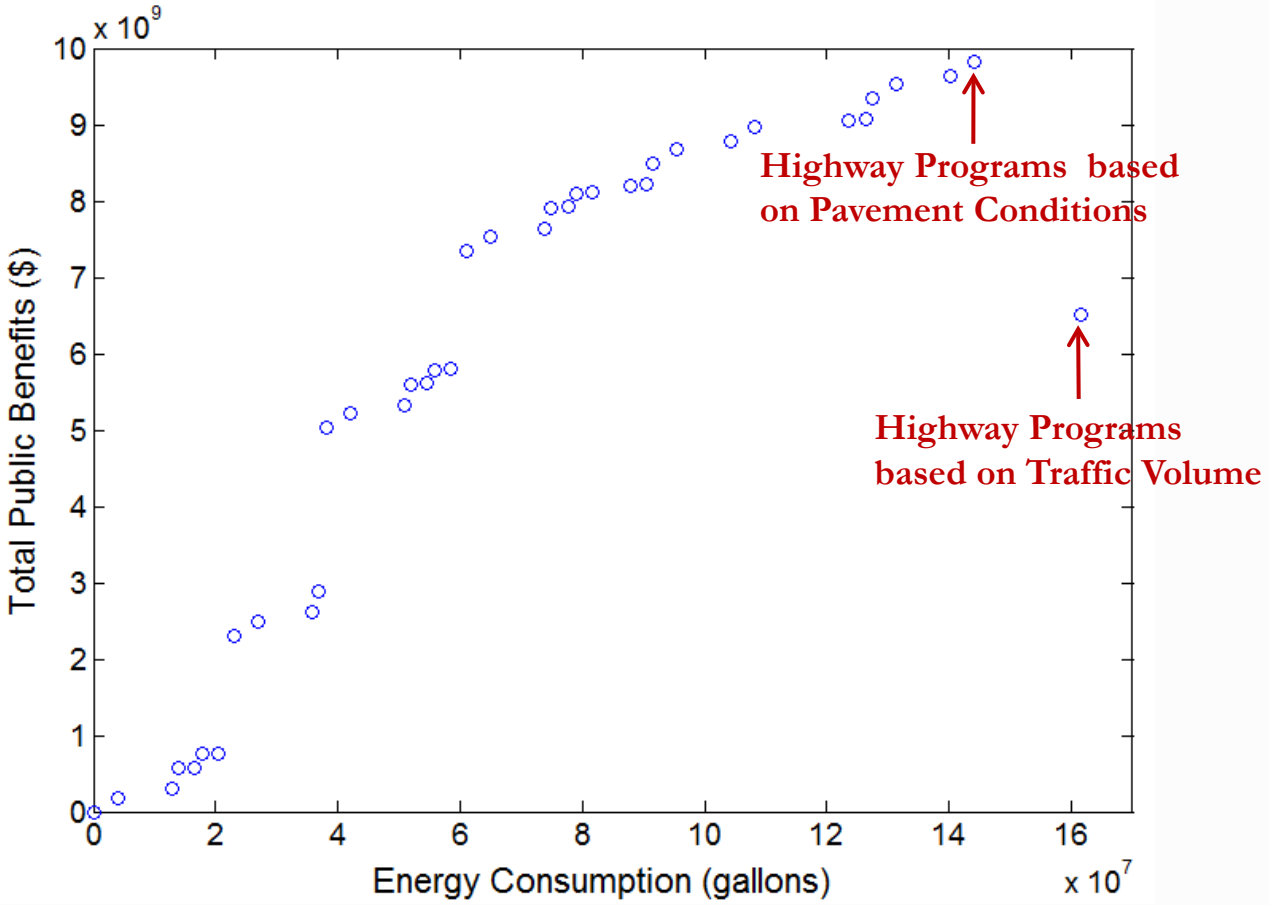
Application Example



Alternative	Project									
	1	2	3	4	5	6	7	8	9	10
1	✓				✓	✓	✓	✓	✓	✓
2		✓	✓	✓		✓		✓	✓	✓

Conclusions

- There is a trade-off between the expected public benefits and network energy consumption.
- The model can provide decision makers with a wide range of optimal solutions that can be effectively selected to satisfy public expectations while minimizing energy consumption.

Future Work

- Expand the optimization scope to be more practicable to transportation agencies' decision making processes.
- Expand the optimization module to include other types of decision variables
  - Prioritizing the competing highway projects
  - Identifying the impact of different rehabilitation methods on highway projects

Thank you for your attention