Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways™

(BE²ST-in-Highways™)

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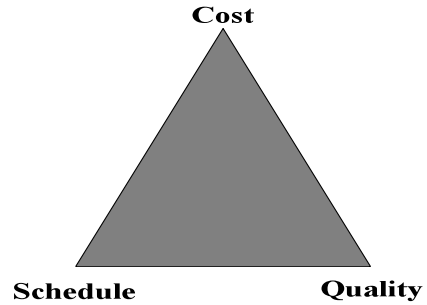
What is sustainable construction?

- **As an action item of *Agenda 21***

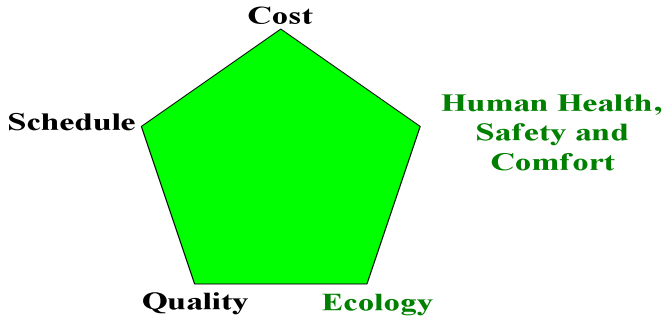
  Promote the increased use of energy-efficient designs and technologies in an economically and environmentally appropriate way (construction industry: activities 7.69 (c))

- **Other key definitions** (Kibert, Gambatese, etc.)
  - 3 Rs (Reduce, Reuse, Recycle)
  - Reduce waste and emission
  - Increase health and safety

Paradigm Shift
(Mendler and Odell 2000)



Old Decision Model



New Decision Model

Why measure it?

- ❑ Verifying the improvement in sustainability
- ❑ Planning and forecasting
- ❑ Competition & Rewarding
- ❑ Regulatory and standards compliance

Image: http://school.discoveryeducation.com/clipart/clip/tapemsr2.html

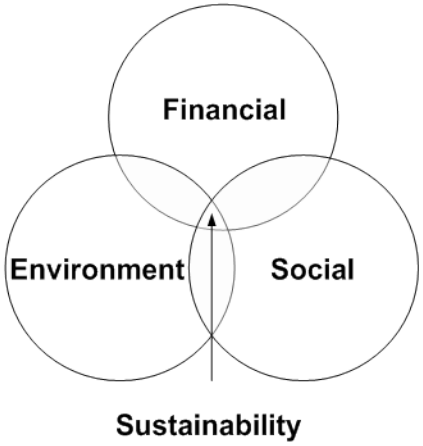
How to measure it?

❑ Coupling of LCA and LCCA

- LCA: a technique to assess the environmental aspects and potential impacts associated with construction projects
- LCCA: a financial-based decision making tool for long-term assessment of construction projects that can be used to systematically determine costs

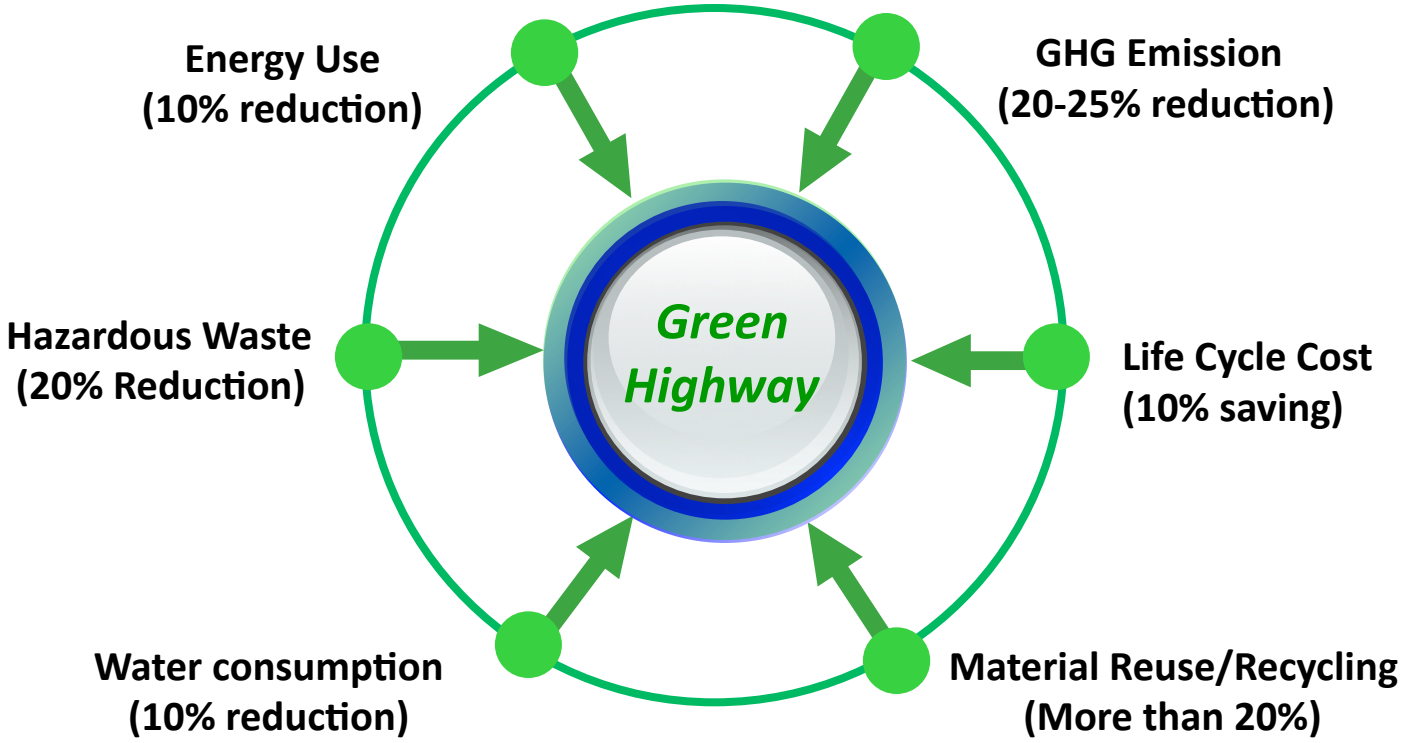
❑ Rating system

- LCA, LCCA, and Social indicators
- Weighting
- Thresholds for labeling
- AMOEBA* to help continuous development

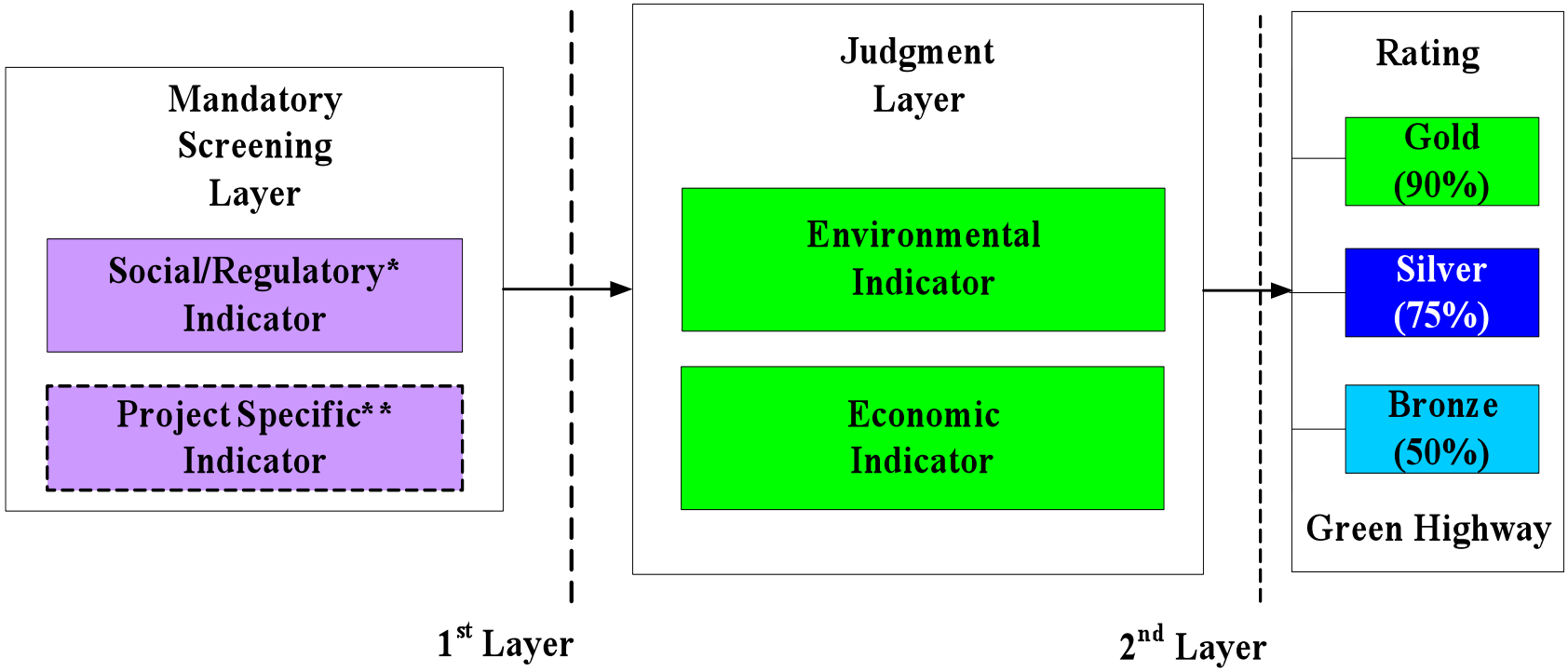


*AMOEBA: general method for ecosystem description and assessment (Dutch)

Target Values of BE²ST-in-Highways™



Structure of BE^{2}ST-in-Highways^{TM}

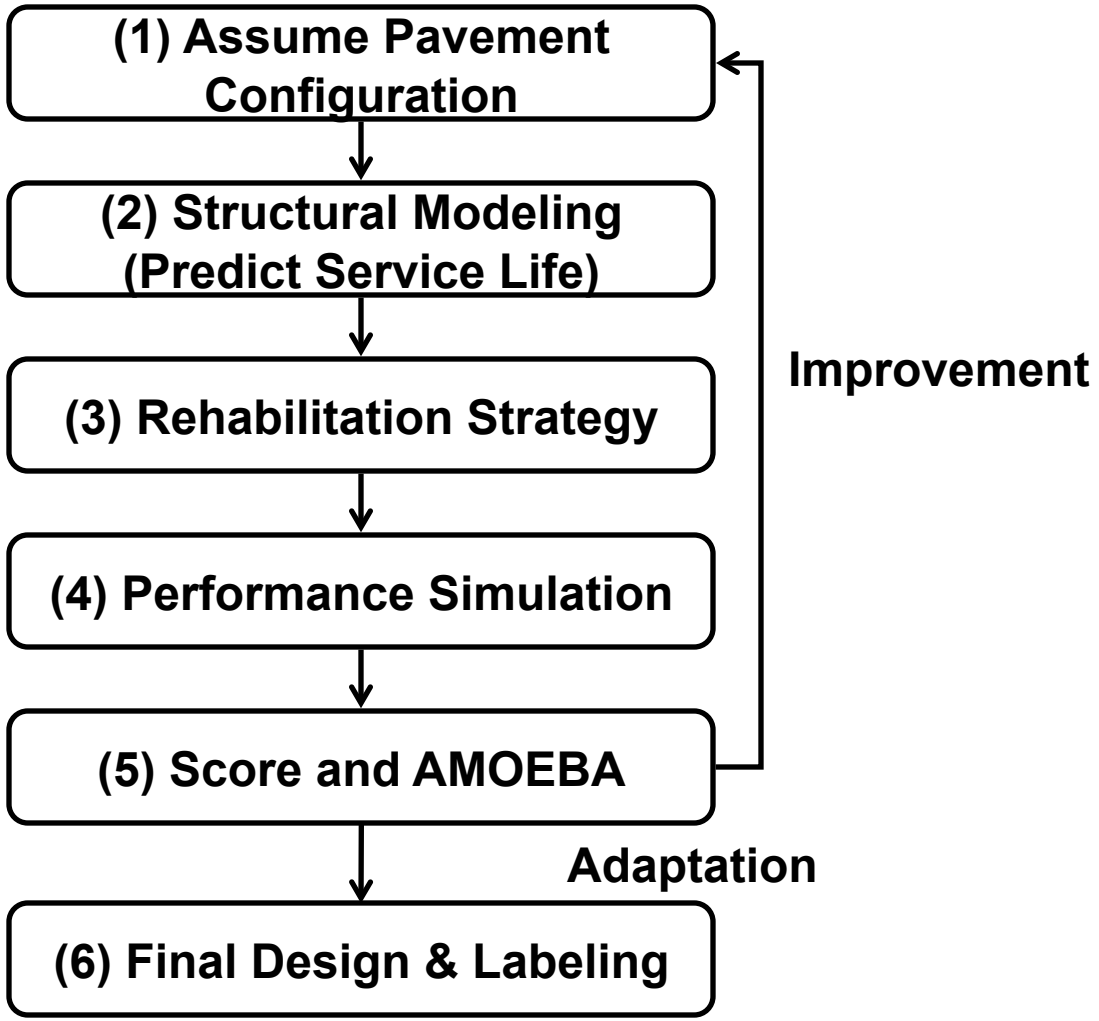


* User needs, laws, local ordinances, and quality requirement

** Preservation of historic site and schedule requirement

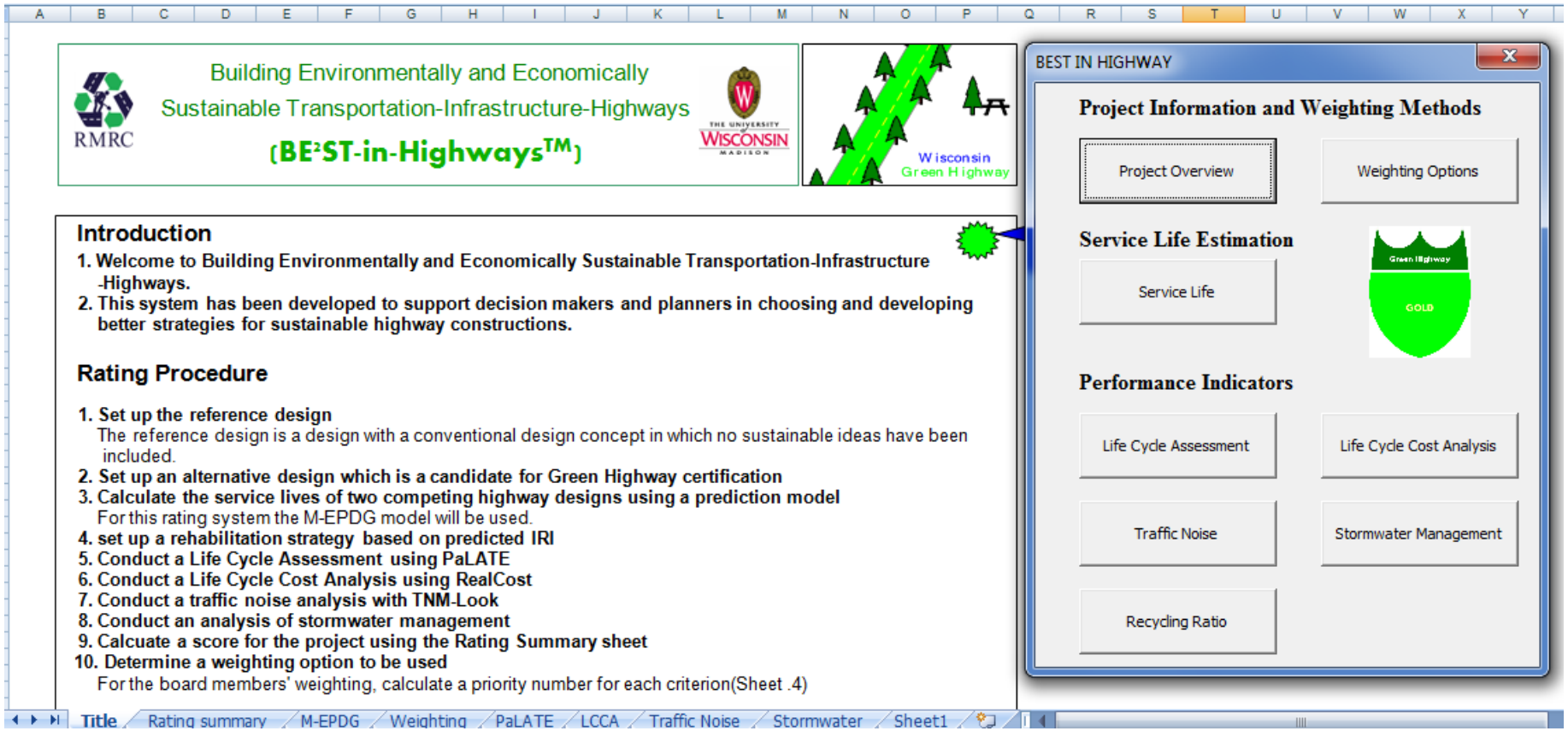
Rating Procedure

- Requirements
  - Transparency
  - Repeatability
  - Considering tradeoffs



The BE²ST-in-Highway™ Software

- **A standard measurement tool to provide transparency/repeatability in rating**



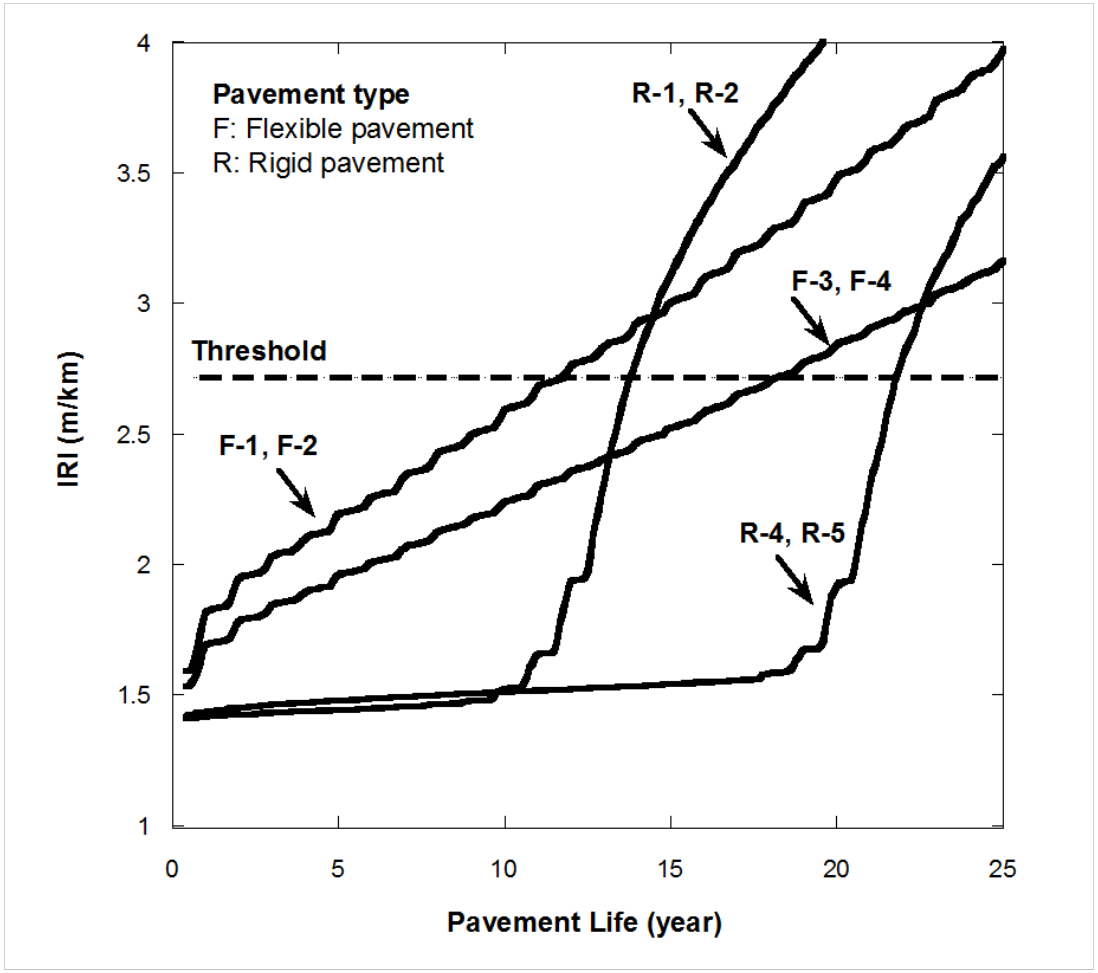
Case Study

- **Schematic of 8 alternative pavement designs for the Baraboo Bypass project**

Design #	Surface type	Recycled material in surface	Thickness of surface (mm)	Base type	Thickness of base (mm)	Recycled Material in base
F-1 Reference	HMA	No	140	Aggregate	152	No
F-2		RAP (15%)	140	Aggregate	152	No
F-3		No	140	RPM with 10% FA	94	RPM with 10% FA
F-4		RAP (15%)	140	RPM with 10% FA	94	RPM with 10% FA
R-1	PCC	FA 15%	254	Aggregate	152	No
R-2		FA 30%	254	Aggregate	152	No
R-3		FA 15%	254	RPM with 10% FA	94	RPM with 10% FA
R-4		FA 30%	254	RPM with 10% FA	94	RPM with 10% FA

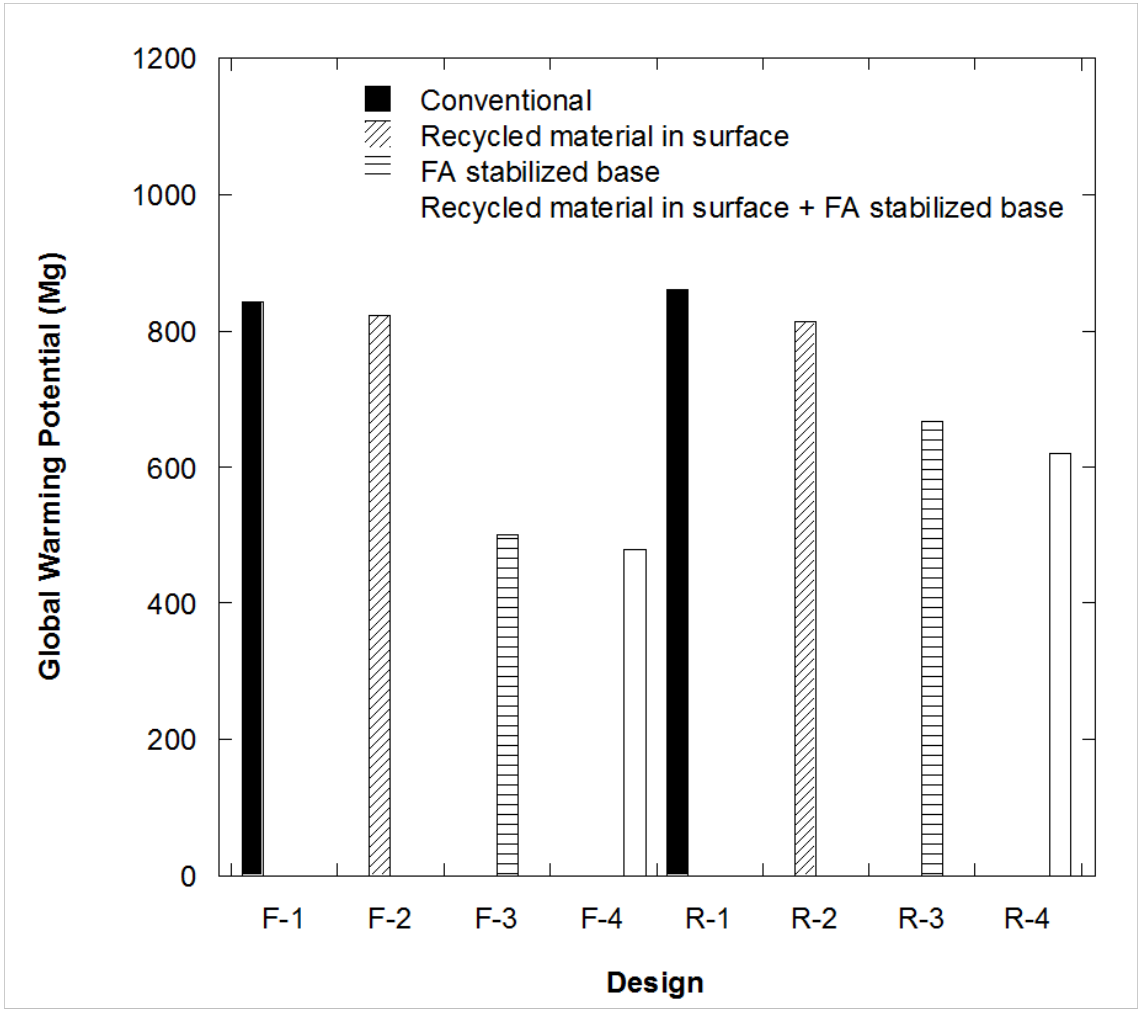
Case Study

- **IRI of the eight alternative designs predicted using M-EPDG**



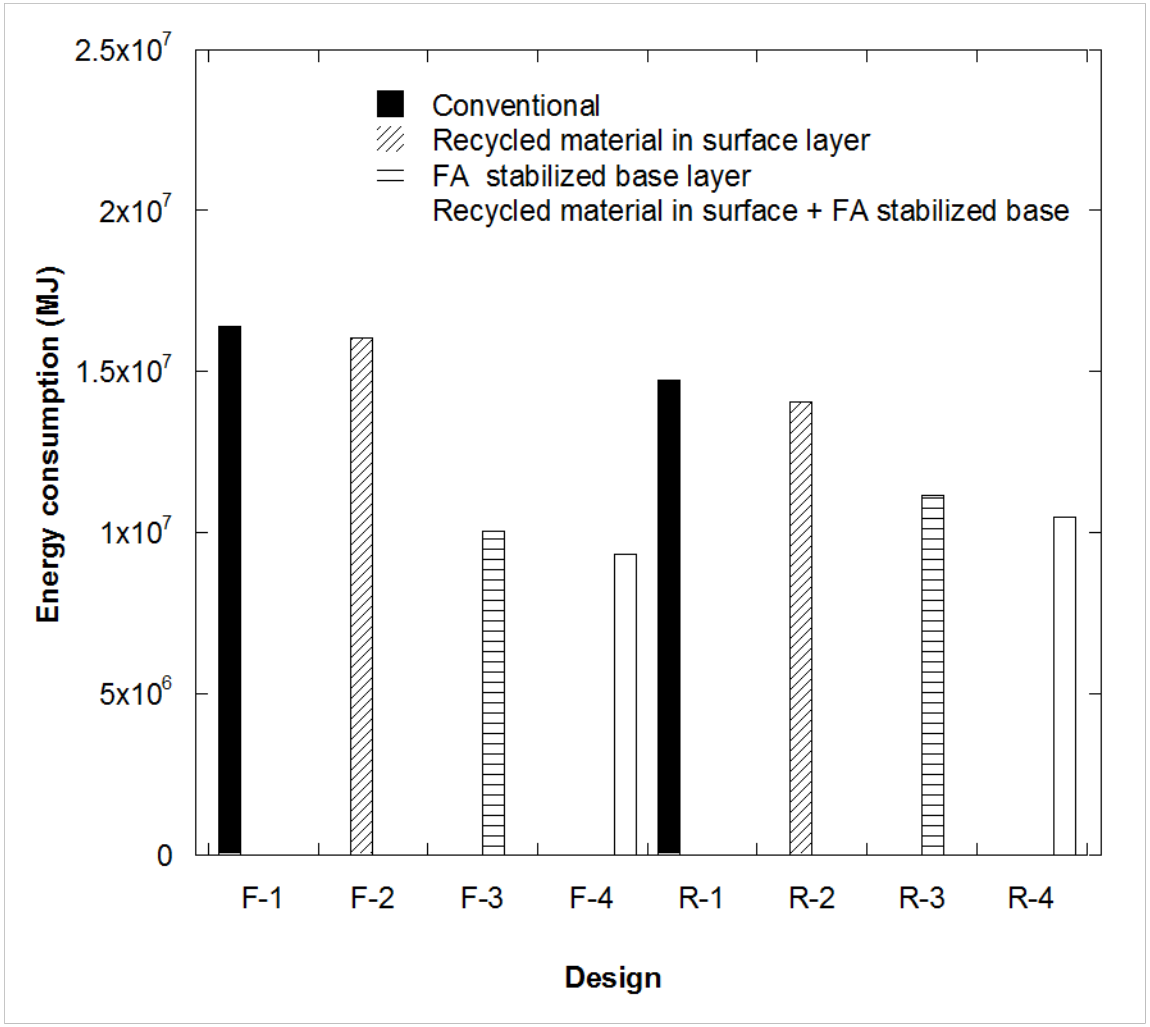
Case Study

- **Global warming potential of the eight alternative designs**



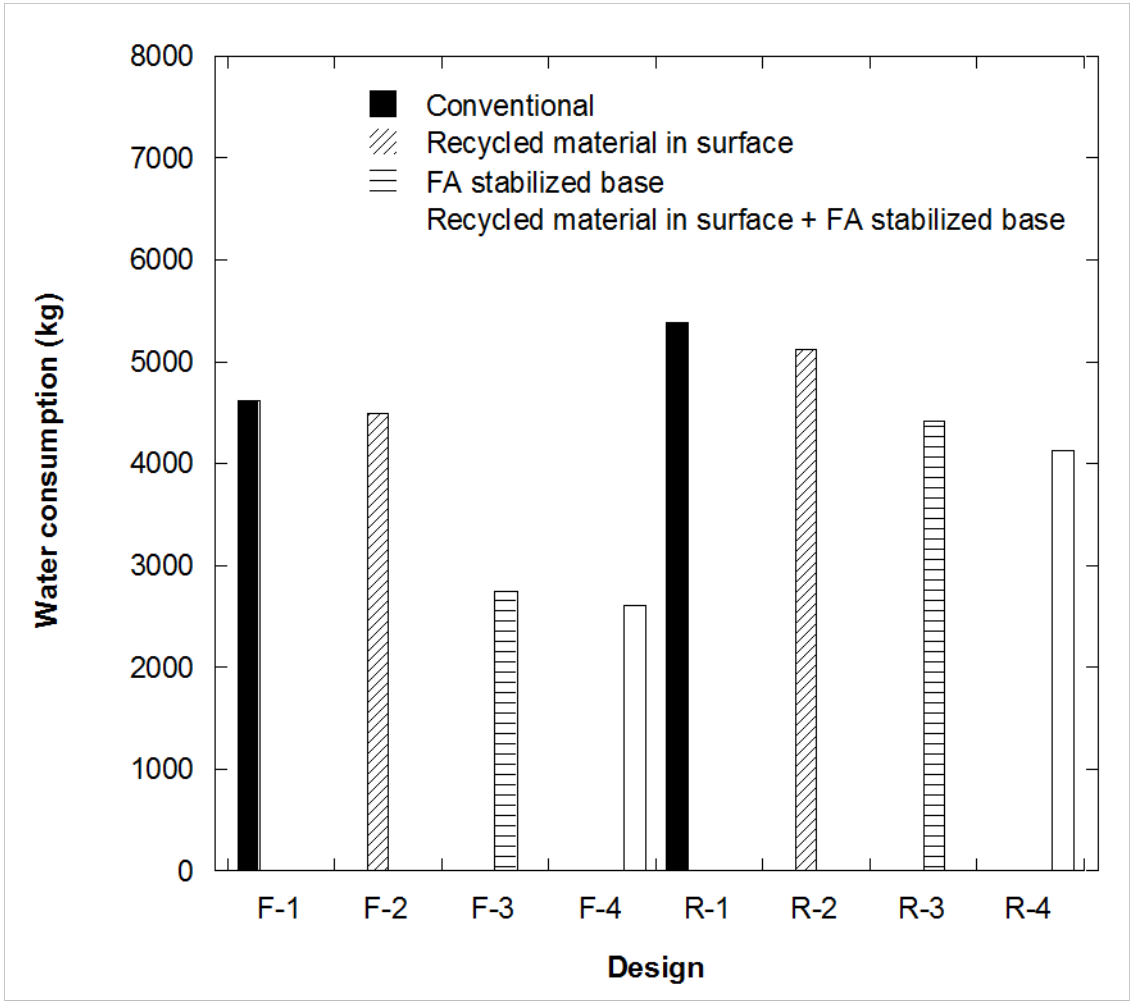
Case Study

- **Energy consumption for the eight alternative designs**



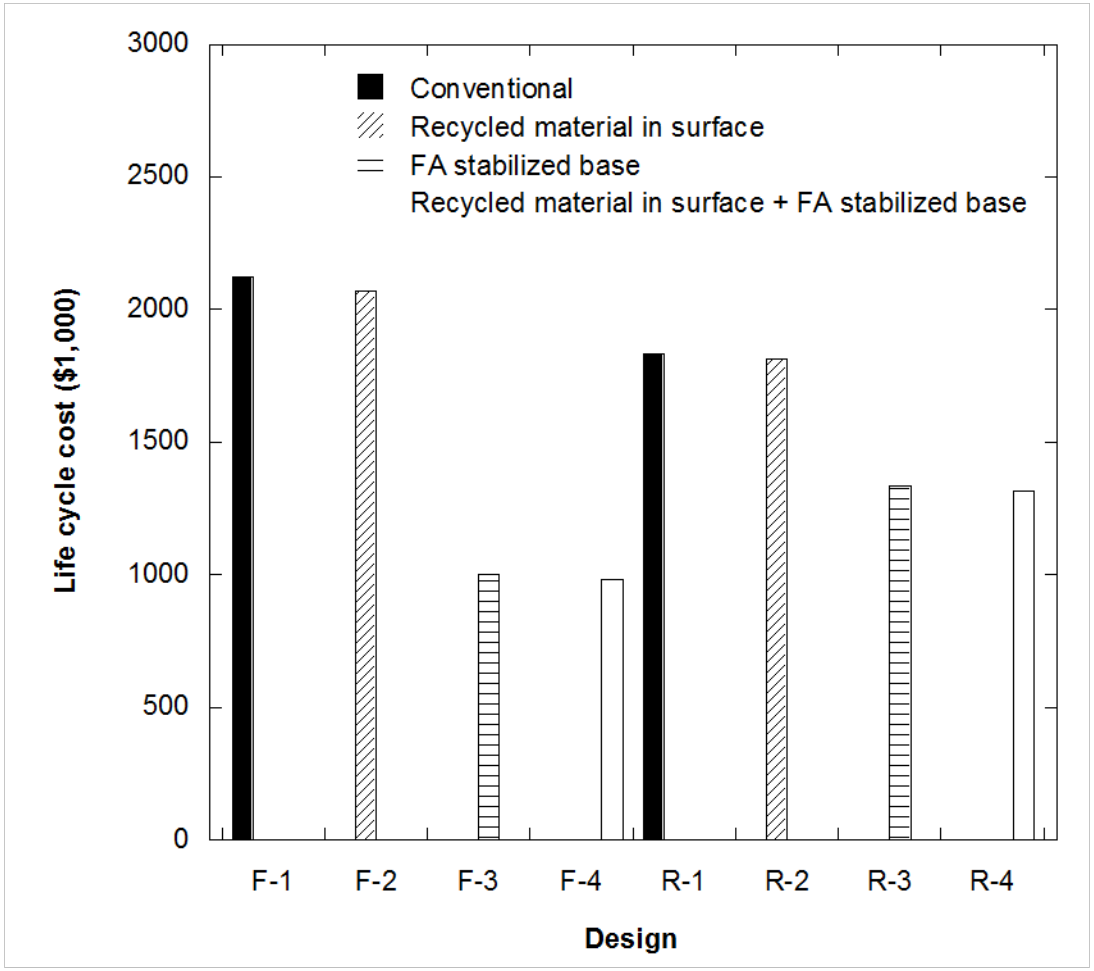
Case Study

- **Water consumption for the eight alternative designs**



Case Study

- **Life cycle cost of the eight alternative designs**



Case Study

❑ **Points obtained and total rating score**

Design	Energy	GWP*	Recycling	Water	LCC **	Traffic Noise	Hazard Material	SCC ***	Total Score
F-2	0.2	0.2	2.2	0.3	0.2	1.0	0.3	0.8	29
F-3	2.0	2.0	4.0	2.0	2.0	1.0	2.0	1.3	91
F-4	2.0	2.0	4.0	2.0	2.0	1.0	2.0	1.4	91
R-1	1.0	0.0	0.4	0.0	2.0	0.0	2.0	0	30
R-2	1.4	0.4	0.7	0.0	2.0	0.0	2	0.1	37
R-3	2.0	2.0	4.0	1.0	2.0	0.0	2.0	0.7	76
R-4	2.0	2.0	2.0	2.0	2.0	0.0	2.0	0.9	72

* GWP: Global Warming Potential, ** LCC: Life Cycle Cost,
*** SCC: Social Cost of Carbon

Case Study

❑ **Final screen shot of the BE²ST-in-Highways™ program for case F-4**

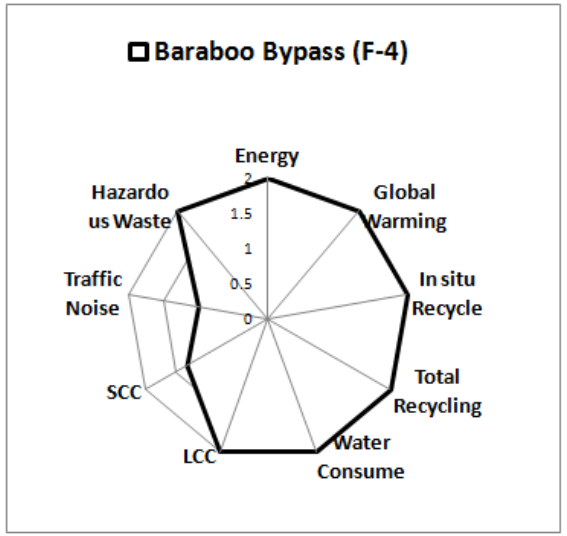
Summary of Rating

Execution

Project Name:	Baraboo Bypass (F-4)
State Route:	US-12
Length:	1 mile
Unit SCC	$69/Mg-CO2

Criteria	Target	Reference	Alternative	Performance
Energy Use (MJ)	>= 10% Reduction (1 pt)	16,953,724	9,674,923	42.93%
	>= 20% Reduction (2 pt)			
GWP (Mg)	>= 10% Reduction (1 pt)	884	506	42.84%
	>= 20% Reduction (2 pt)			
In Situ Recycling (CY)	>= 10% Recycling Rate (1 pt)	0.00	1302.40	36.20%
	>= 20% Recycling Rate (2 pt)			
Total Recycling (CY)	>= 10% Recycled Content (1 pt)	0.00	1769.78	49.18%
	>= 20% Recycled Content (2 pt)			
Water Consumption (kg)	>= 5% Reduction (1 pt)	4,702	2,660	43.42%
	>= 10% Reduction (2 pt)			
Life Cycle Cost ($)	>= 5% Reduction (1 pt)	$2,121,147	$983,868	53.62%
	>= 10% Reduction (2 pt)			
Social Carbon Cost ($)	>= $19,750/mi Saving (1 pt)	$60,996	$34,914	$26,082
	>= $39,500/mi Saving (2 pt)			
Traffic Noise (no unit)	HMA (1 pt)	-	1	1
	SMA or OGFC (2 pt)			
Hazardous Waste (kg)	>= 10% Reduction (1 pt)	181,991	104,348	42.66%
	>= 20% Reduction (2 pt)			

Accomplished Score	90.69
Awarded Label	Green Highway Gold



Title | Rating summary | M-EPDG | Weighting | PaLATE | LCCA | Traffic Noise | Stormwater | Sheet1

SMA: Stone Matrix Asphalt
OGFC: Open Graded Friction Courses

Conclusion

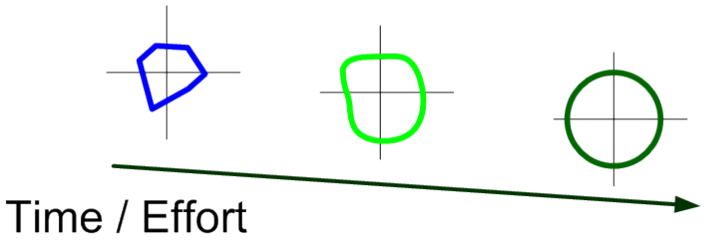
- **Case study using BE²ST-in-Highways™ reveals**
  - **Modest changes only to a pavement design yield significant environmental and economic benefits**
    - ✓ 43% reduction in energy and GWP, 54% reduction in LCC
  - **The superior material properties of some recycled materials**
    - ✓ Reduce the amount of material consumption

    or

    - ✓ Extend the service life of the highway structure

    Thus, less adverse environmental impacts and lower life-cycle cost

- **BE²ST-in-Highways™ supports continuous project improvement**



Questions & Comments !