



Building Environmentally and Economically Sustainable Transportation-Infrastructure- HighwaysTM (BE²ST-in-HighwaysTM)

Presented by: Tuncer B. Edil, PhD, PE, D. GE

**Recycling Materials Resource Center/University of
Wisconsin-Madison**

What is sustainable construction?

❑ As an action item of *Agenda 21*

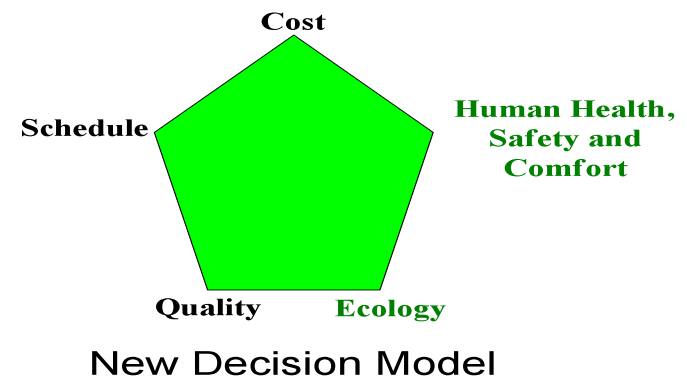
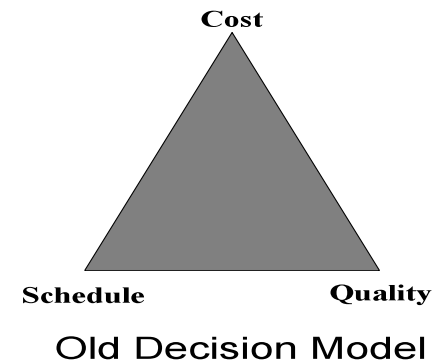
Promote the increased use of energy-efficient designs and technologies in an economically and environmentally appropriate way (construction industry: activities 7.69 (c))

❑ 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)



Why measure it?

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



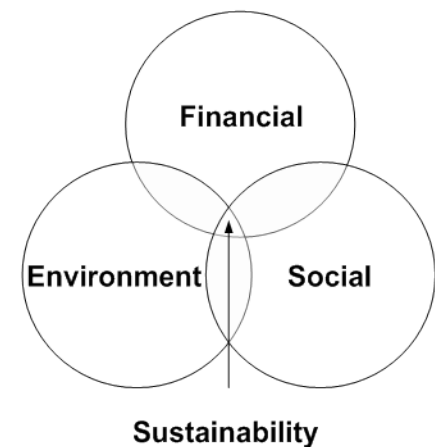
How to measure it?

□ 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

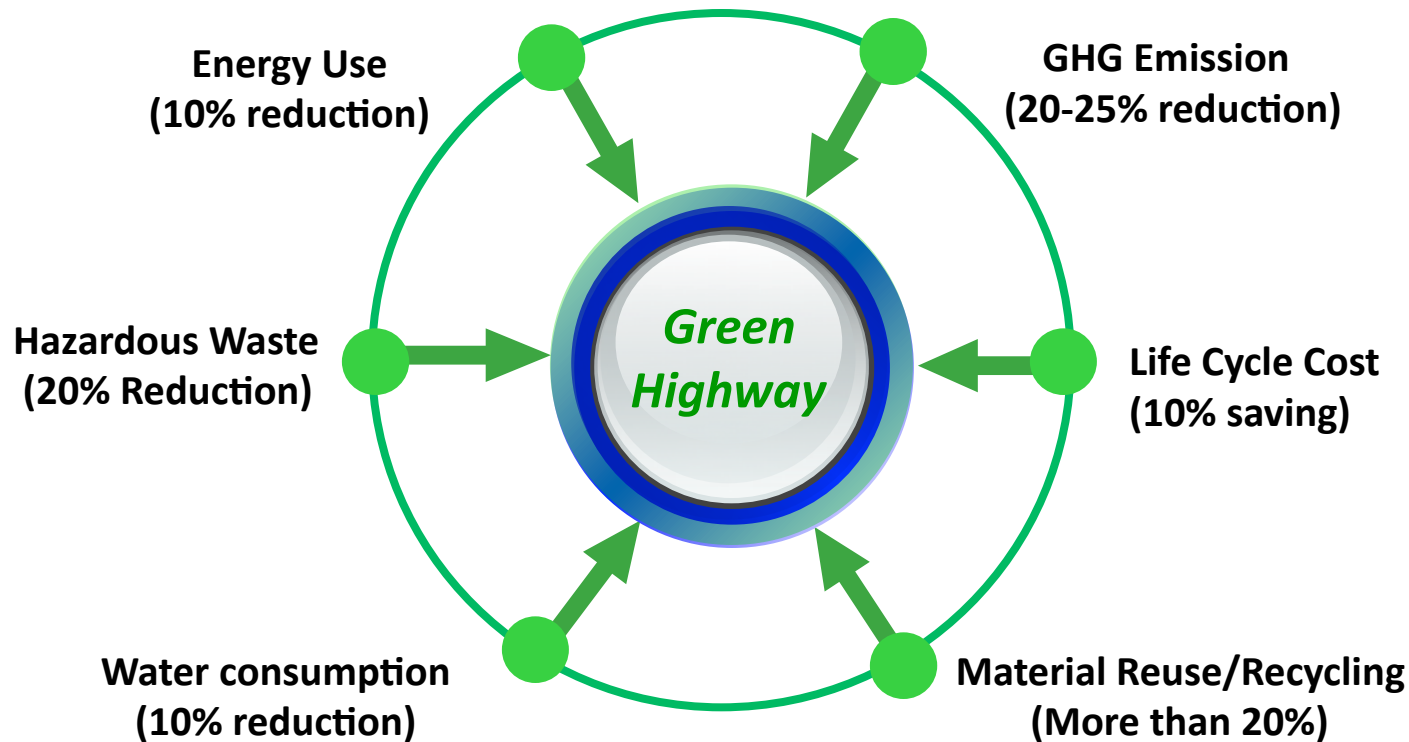
□ Rating system

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

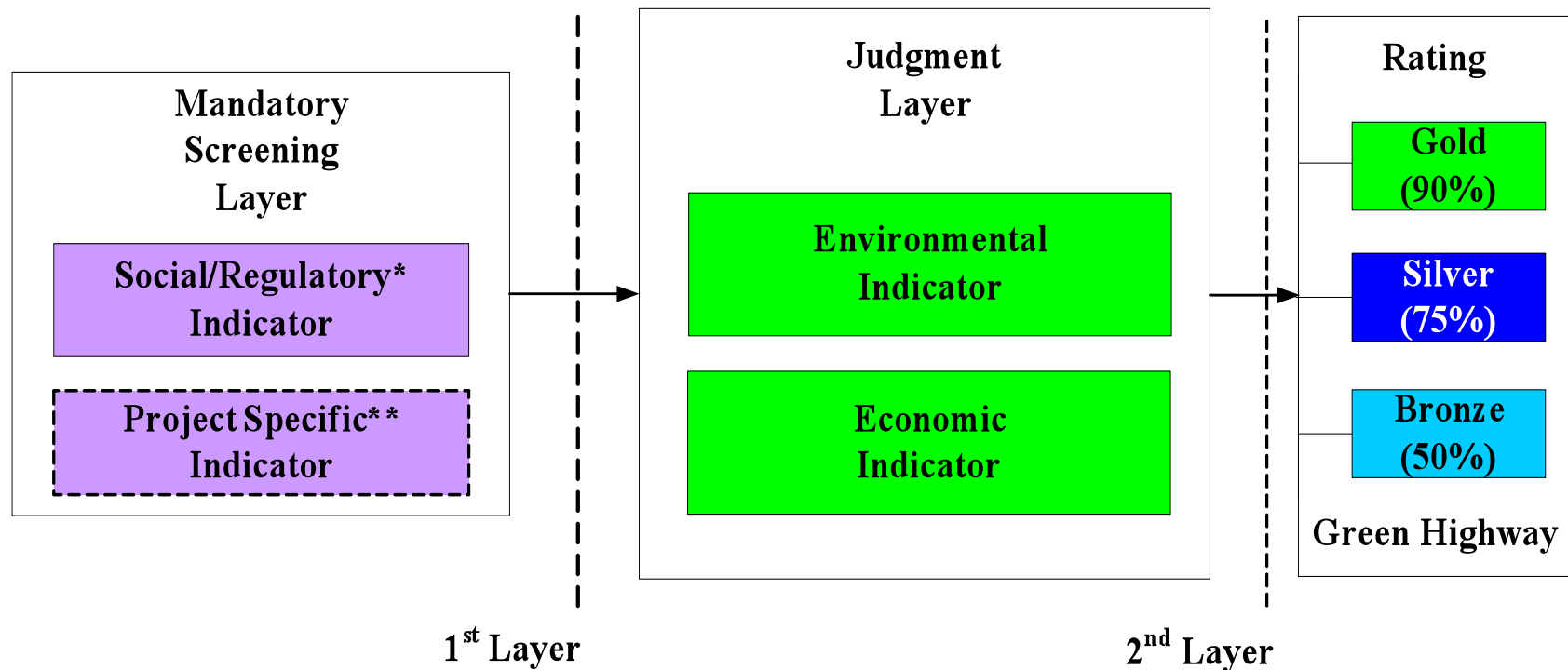


*AMOEBA: general method for ecosystem description and assessment (Dutch)

Target Values of BE²ST-in-Highways™



Structure of BE²ST-in-Highways™



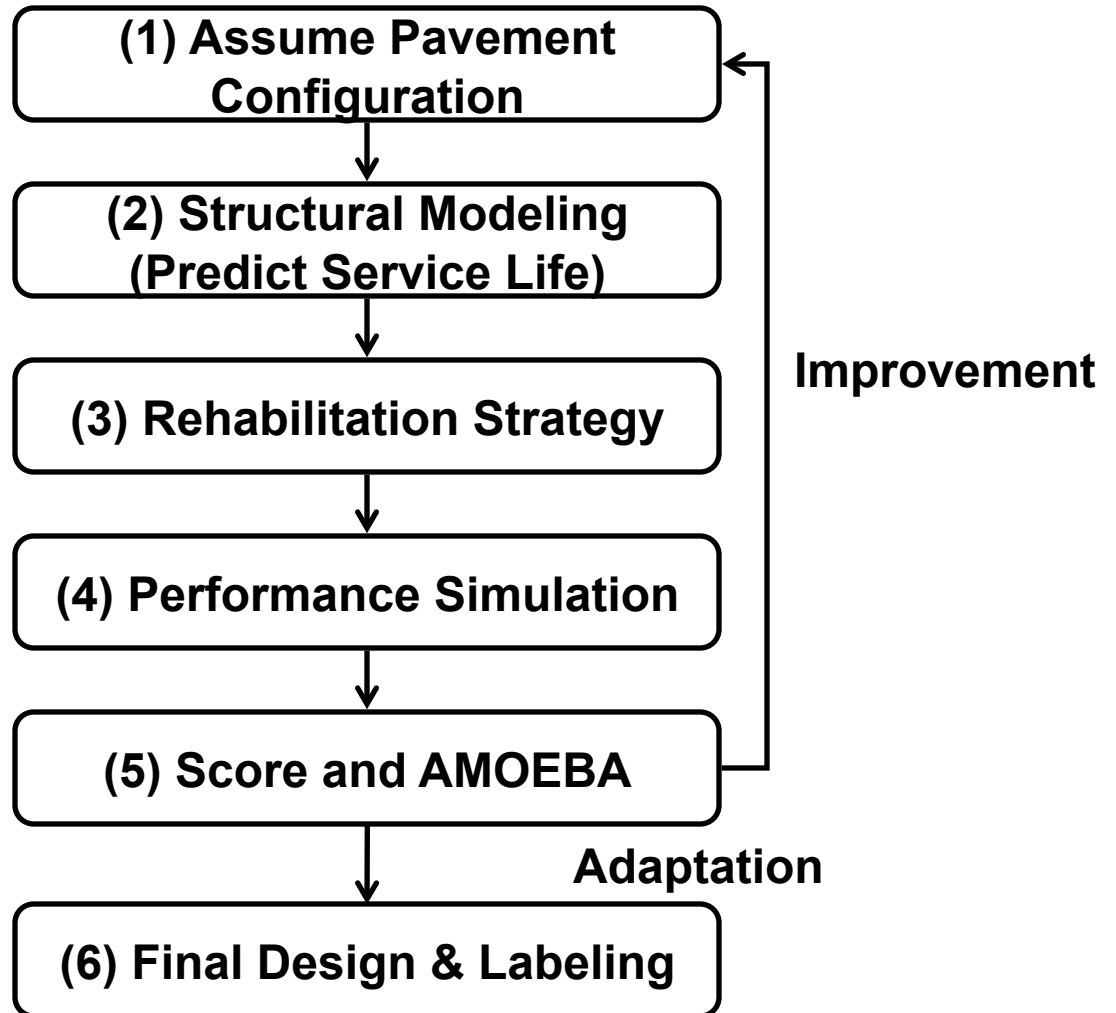
* User needs, laws, local ordinances, and quality requirement

** 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

The screenshot displays the BE²ST-in-Highway™ Software interface, which is presented as a spreadsheet application. The main window shows a spreadsheet with columns A through Y. The active sheet is titled 'Rating summary'. The interface includes a header banner with the RMRC logo, the text 'Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways (BE²ST-in-Highways™)', and the University of Wisconsin-Madison logo. A 'Wisconsin Green Highway' graphic is also visible. The 'Introduction' section provides a welcome message and states that the system is designed to support decision makers and planners in choosing and developing better strategies for sustainable highway constructions. The 'Rating Procedure' section lists 10 steps for the rating process, including setting up reference and alternative designs, calculating service lives, and conducting various assessments. A 'BEST IN HIGHWAY' dialog box is open on the right side of the spreadsheet. This dialog box contains sections for 'Project Information and Weighting Methods' (with buttons for 'Project Overview' and 'Weighting Options'), 'Service Life Estimation' (with a 'Service Life' button and a 'Green Highway GOLD' shield icon), and 'Performance Indicators' (with buttons for 'Life Cycle Assessment', 'Life Cycle Cost Analysis', 'Traffic Noise', 'Stormwater Management', and 'Recycling Ratio'). The spreadsheet's status bar at the bottom shows the current sheet is 'Sheet1' and lists various tabs: 'Title', 'Rating summary', 'M-EPDG', 'Weighting', 'PaLATE', 'LCCA', 'Traffic Noise', 'Stormwater', and 'Sheet1'.

Introduction

1. Welcome to Building Environmentally and Economically Sustainable Transportation-Infrastructure-Highways.
2. This system has been developed to support decision makers and planners in choosing and developing better strategies for sustainable highway constructions.

Rating Procedure

1. Set up the reference design
The reference design is a design with a conventional design concept in which no sustainable ideas have been included.
2. Set up an alternative design which is a candidate for Green Highway certification
3. Calculate the service lives of two competing highway designs using a prediction model
For this rating system the M-EPDG model will be used.
4. set up a rehabilitation strategy based on predicted IRI
5. Conduct a Life Cycle Assessment using PaLATE
6. Conduct a Life Cycle Cost Analysis using RealCost
7. Conduct a traffic noise analysis with TNM-Look
8. Conduct an analysis of stormwater management
9. Calculate a score for the project using the Rating Summary sheet
10. Determine a weighting option to be used
For the board members' weighting, calculate a priority number for each criterion(Sheet .4)

BEST IN HIGHWAY

Project Information and Weighting Methods

- Project Overview
- Weighting Options

Service Life Estimation

- Service Life
- Green Highway GOLD

Performance Indicators

- Life Cycle Assessment
- Life Cycle Cost Analysis
- Traffic Noise
- Stormwater Management
- Recycling Ratio

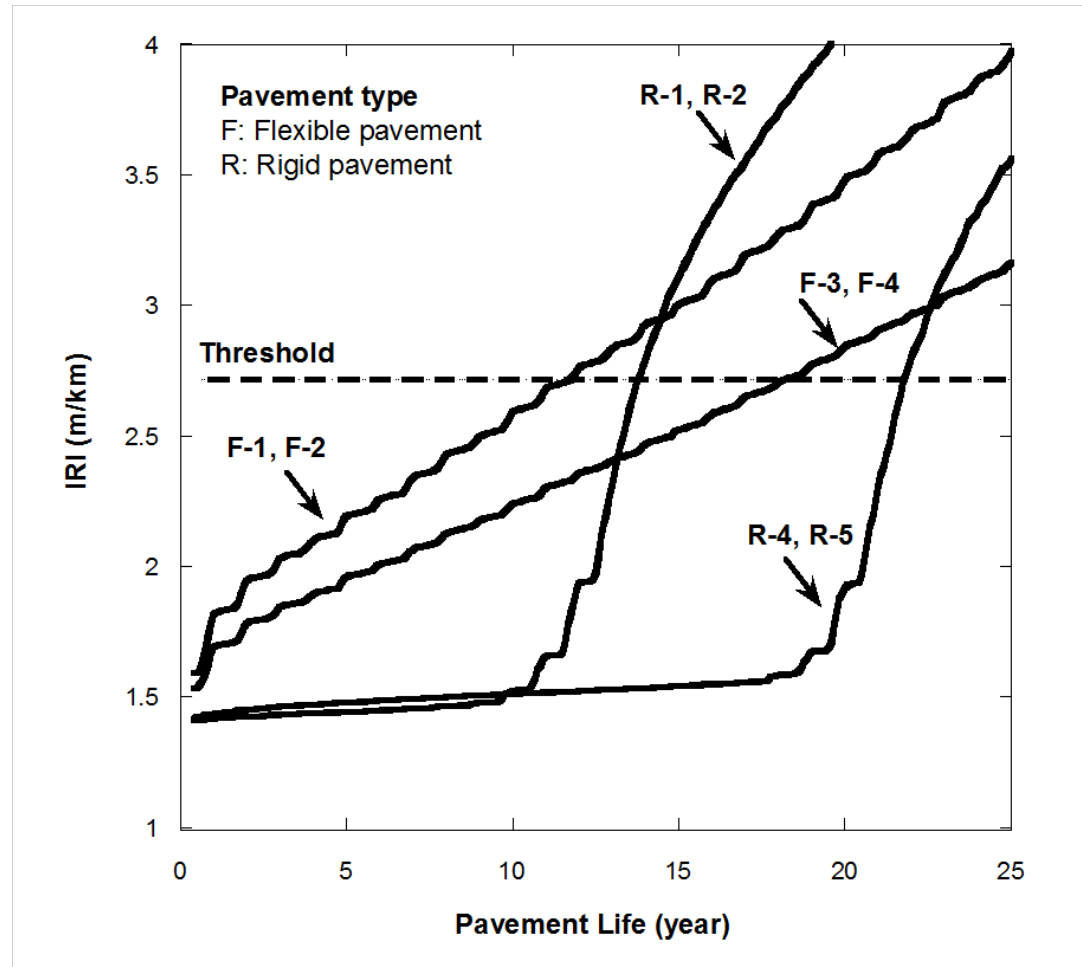
Case Study

□ 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

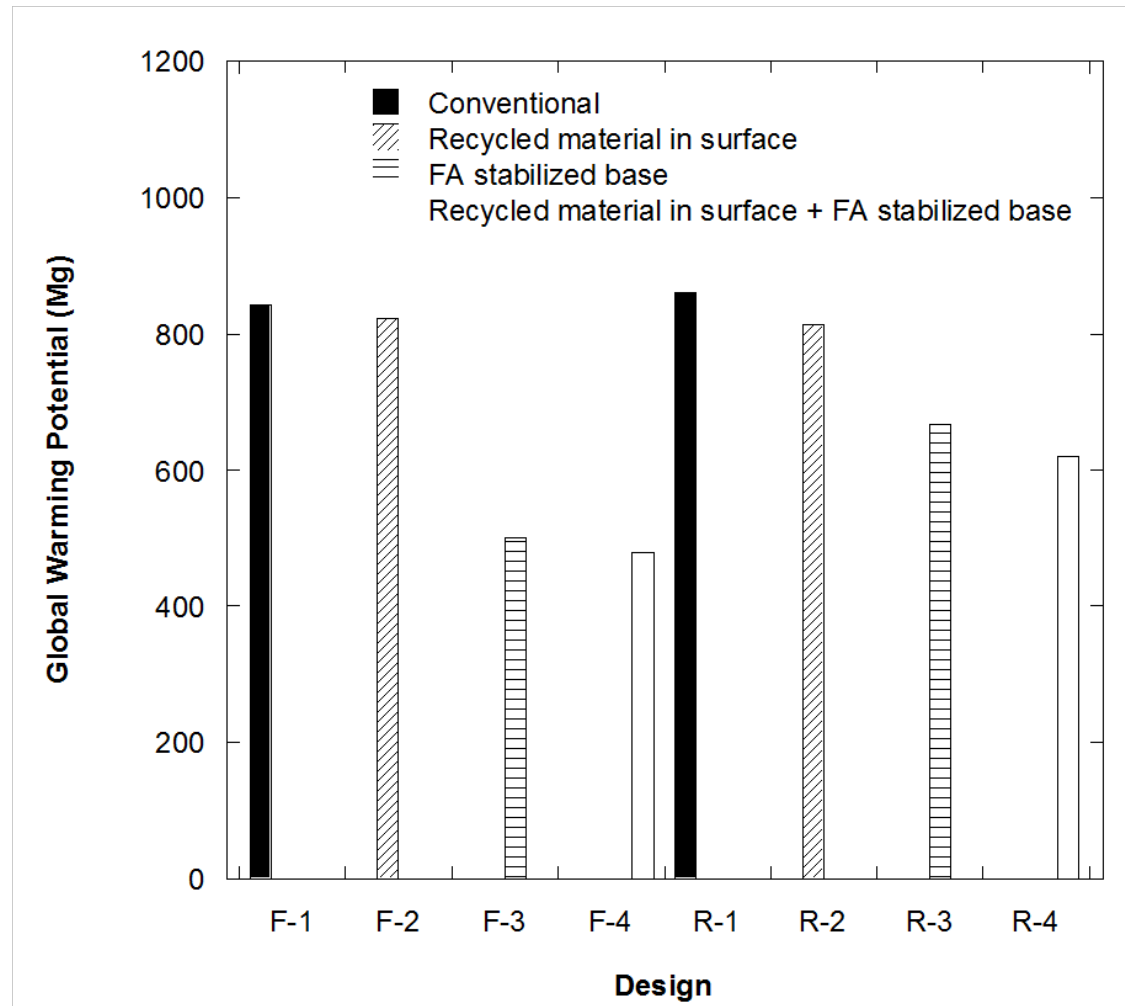
Case Study

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



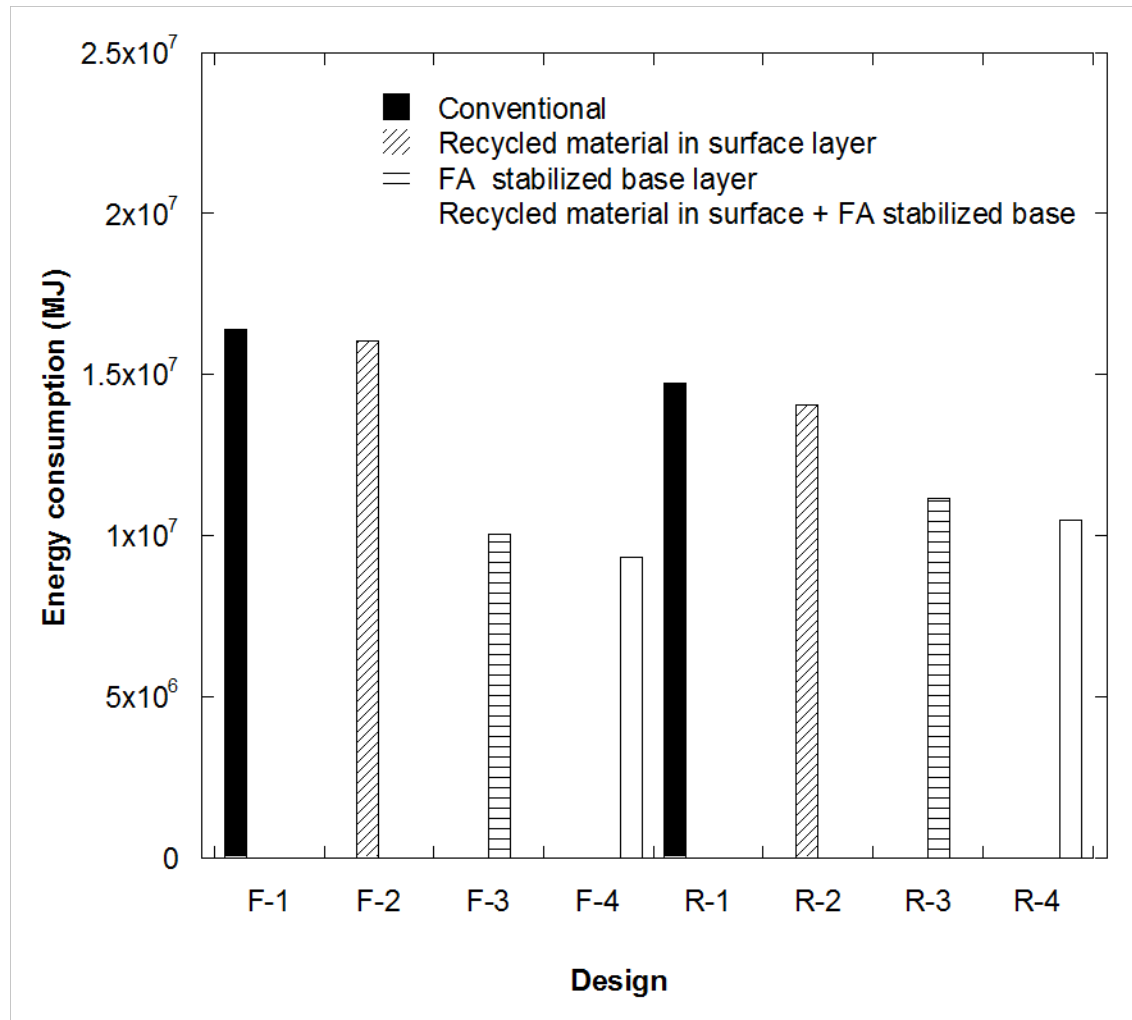
Case Study

□ Global warming potential of the eight alternative designs



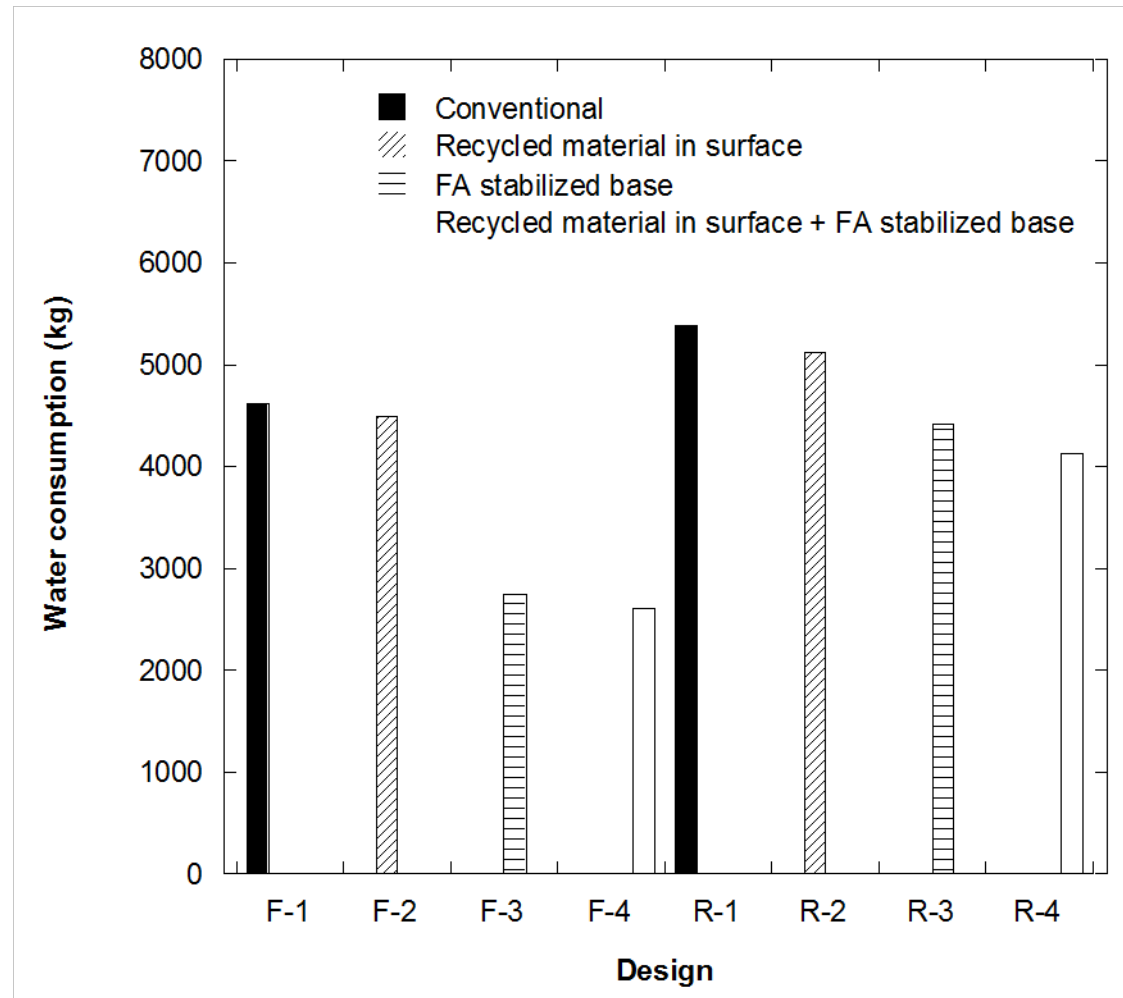
Case Study

□ Energy consumption for the eight alternative designs



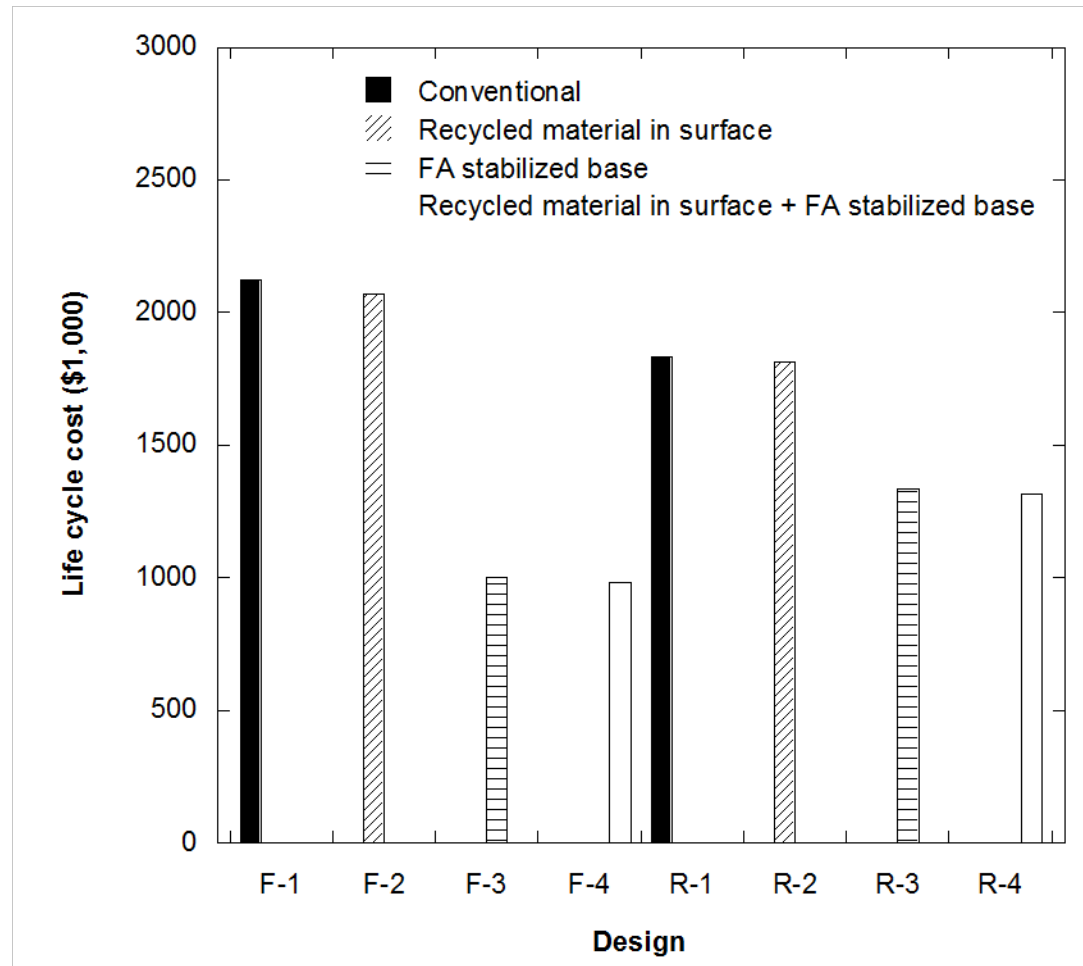
Case Study

❑ 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

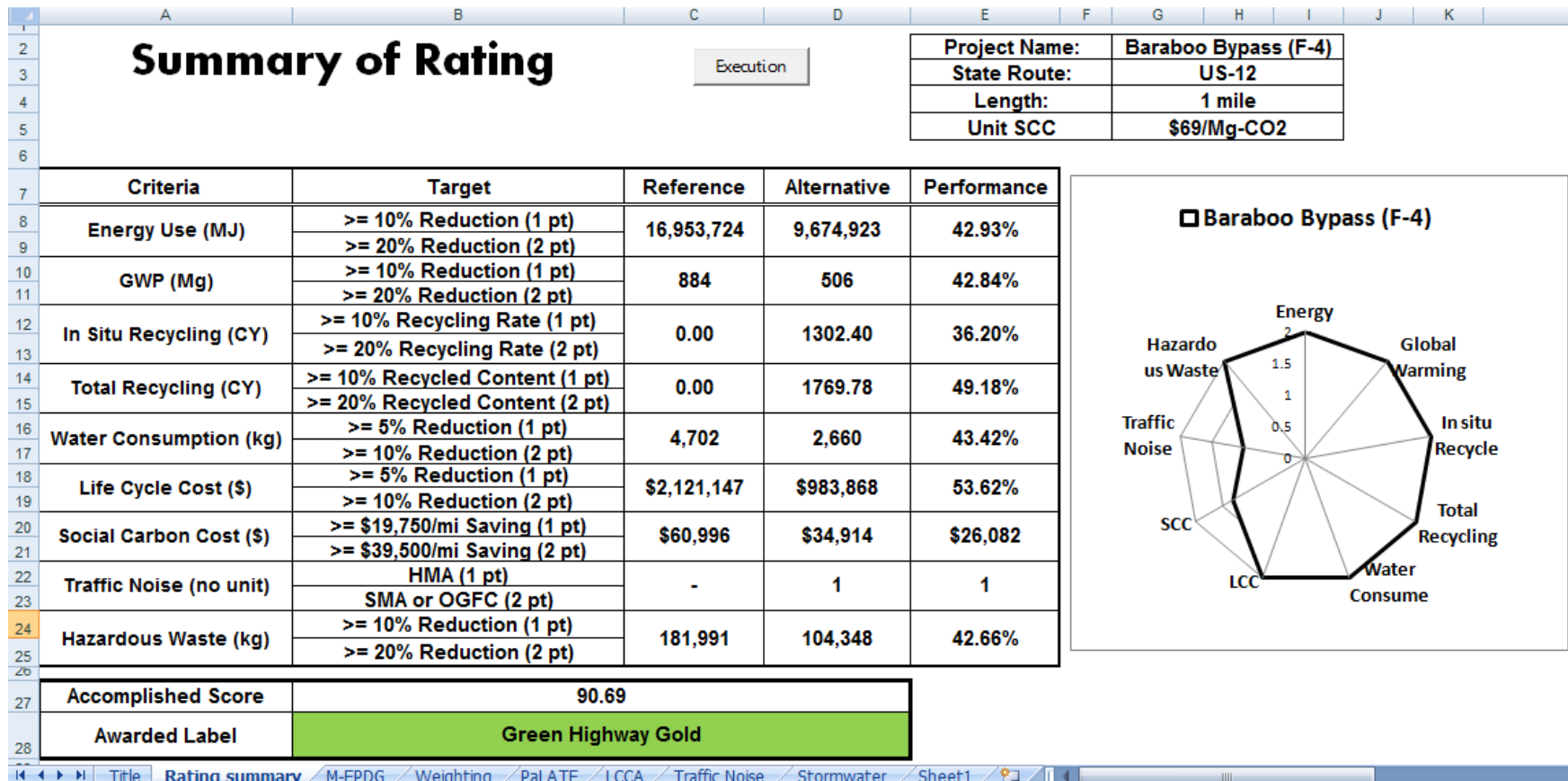
Design	Energy	GWP*	Recycling	Water	LCC**	Traffic Noise	Hazard Material	SCC***	Total Score
F-2	0.2	0.2	2.2	0.3	0.2	1.0	0.3	0.8	29
F-3	2.0	2.0	4.0	2.0	2.0	1.0	2.0	1.3	91
F-4	2.0	2.0	4.0	2.0	2.0	1.0	2.0	1.4	91
R-1	1.0	0.0	0.4	0.0	2.0	0.0	2.0	0	30
R-2	1.4	0.4	0.7	0.0	2.0	0.0	2	0.1	37
R-3	2.0	2.0	4.0	1.0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



SMA: Stone Matrix Asphalt

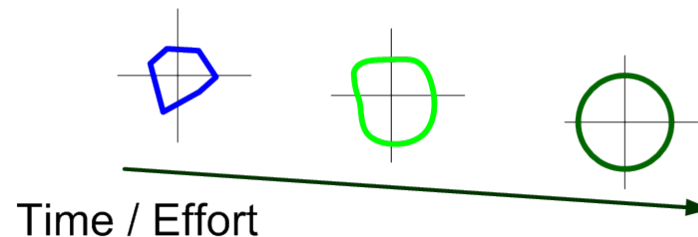
OGFC: Open Graded Friction Courses

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 !