CAPITALIZING GREEN PAVEMENT
A METHOD AND VALUATION

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Presentation Overview

1. Problem
2. Big Ideas
3. Voluntary Carbon Markets
4. Pavement Performance Benchmark
5. Conclusion

Hot-mixed vs foamed asphalt (HMA vs FSB)

1/5: PROBLEM

HMA

HMA

90%

Paved roads in US, Canda, and Europe

Magnum 2006

HMA

90%

Paved roads in US, Canda, and Europe

Magnum 2006

317

Mt produced each year in the U.S.

NAPA 2015
(in metric)

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Paved roads in US, Canda, and Europe

Magnum 2006

317

Mt produced each year in the U.S.

NAPA 2015
(in metric)

+4

Other pollutants: CO, NO_2, SO_2, various organic compounds

Truit 2009

HMA

90%

Paved roads in US, Canda, and Europe

Magnum 2006

317

Mt produced each year in the U.S.

NAPA 2015
(in metric)

+4

Other pollutants: CO, NO_2, SO_2, various organic compounds

Truit 2009

3x

More GHG/$ spent than power and communication lines

Truit 2009

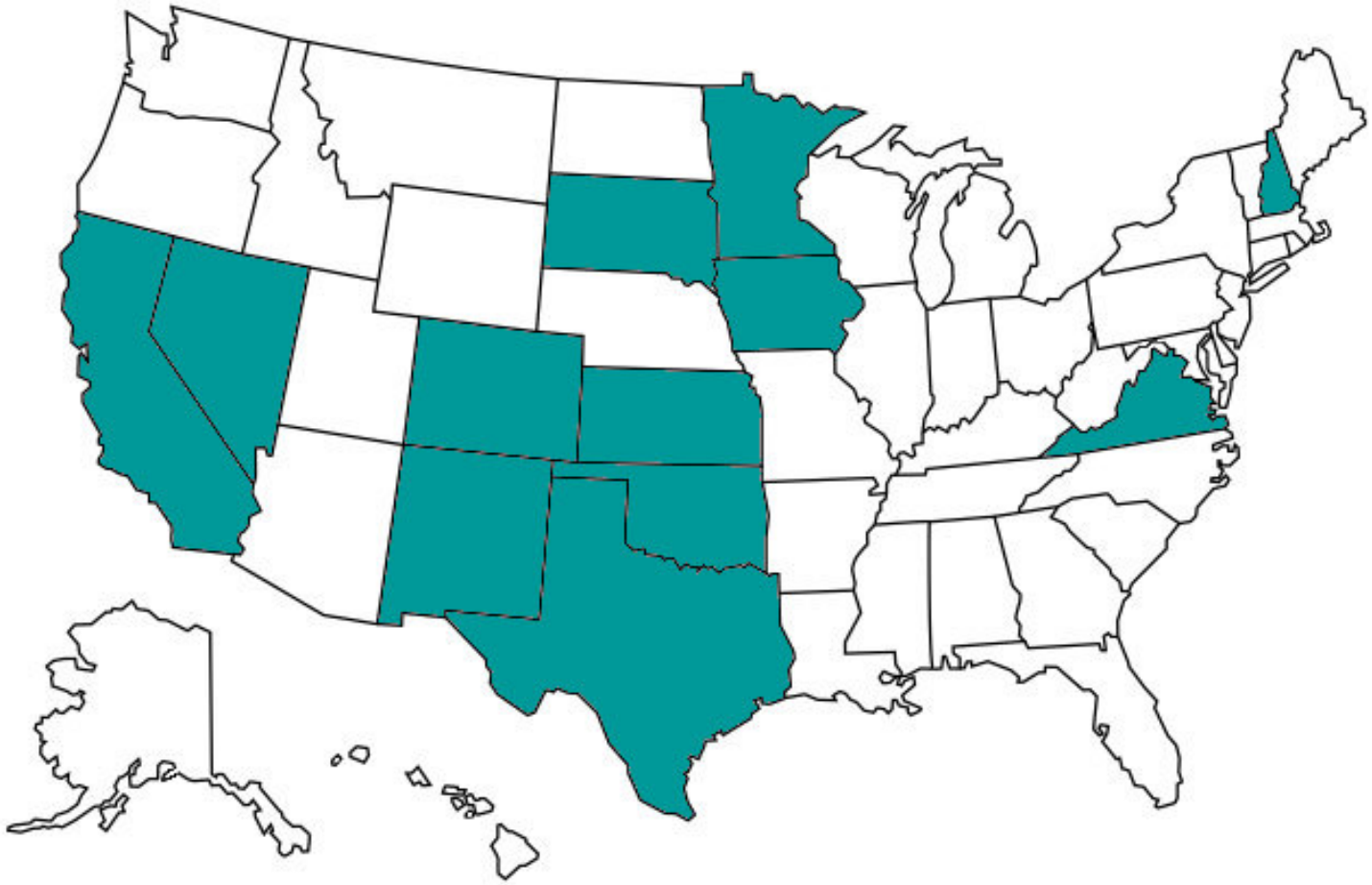
Hot Mix vs Foam Stabilized Base (FSB)

	HMA	FSB
Aggregate	Virgin & Recycled	100% Recycled
Cost	$$	$
Mix temperature	High	Low (Ambient)
Hauling	More	Less
Use	High	Low
Thickness	Standard	A bit more

Interstate Highway Projects

Only eleven states use recycled materials on interstate highway projects

Image credit: Brian Diefenderfer, PhD, PE, Virginia Transportation Research Council (September 2016)



FSB Example:
I-64 Highway: Restoration & Widening

Project

- $190 million
- Reconstruction of 7.08 miles (3,000+ trucks/day)
- Addition of a 12ft shoulder

Estimated Impact

- 30 to 50% cost savings
- 50% less greenhouse gasses*
- Fixes deterioration causes, not just symptoms
- Faster than full reconstruction

** initial estimate; I believe actual results will vary*

Full Depth Reclamation (FDR)

Recycles materials on-site

1. Pulverize existing asphalt + underlying base (4 to 12 inches)
2. Treat reclaimed material with additives
3. Compact (drum or pneumatic tire roller)
4. Apply a surface layer

Image credit: Brian Diefenderfer, PhD, PE, Virginia Transportation Research Council (September 2016)

Cold Central Plant Recycling (CCPR)

Recycles materials in a central place

- In urban areas, central plants can stockpile RAP from contractors that have excess amounts
- Normally requires hauling/fuel
- Mobile mix plants reduce hauling

Image courtesy of Global Resource Recyclers Engineering (2017)

FSB Barriers and Drivers

Barriers

- Business as usual in the U.S.
- Unregulated CO_2 markets
- Equipment / re-tooling
- Training
- No consensus on use or structural performance

Drivers

- Low cost of recycled materials
- Environmental goodwill?
- Q: WHAT GOES HERE?
-

Voluntary Markets & App

2/5: THE BIG IDEAS

Two Ideas to Drive Adoption

1. Economic
2. Social

Two Ideas to Drive Adoption

1. Economic: Voluntary Carbon Market
2. Social: App

THIS PRESENTATION

LATER:
ENCOURAGE FSB DESIGN
W/ WEB-BASED CAD

Baselines and Performance Benchmarks for

3/5: VOLUNTARY CARBON MARKETS

Voluntary Carbon Market Projects

1. Projects reduce CO_2 emissions
2. Standard organizations verify reductions and award carbon offset credits
3. Credits are sold at market prices

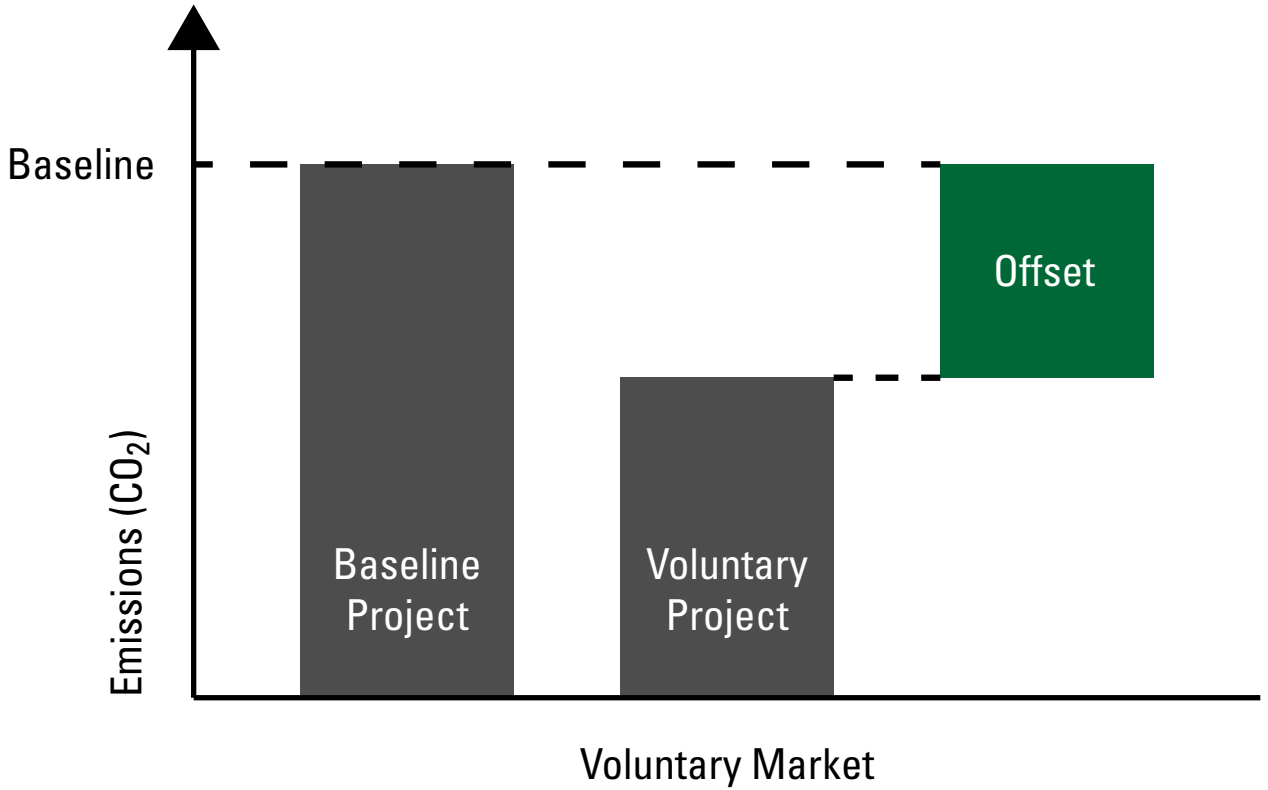
HOW DO ORGANIZATIONS VERIFY REDUCTIONS?

Voluntary Carbon Market Projects

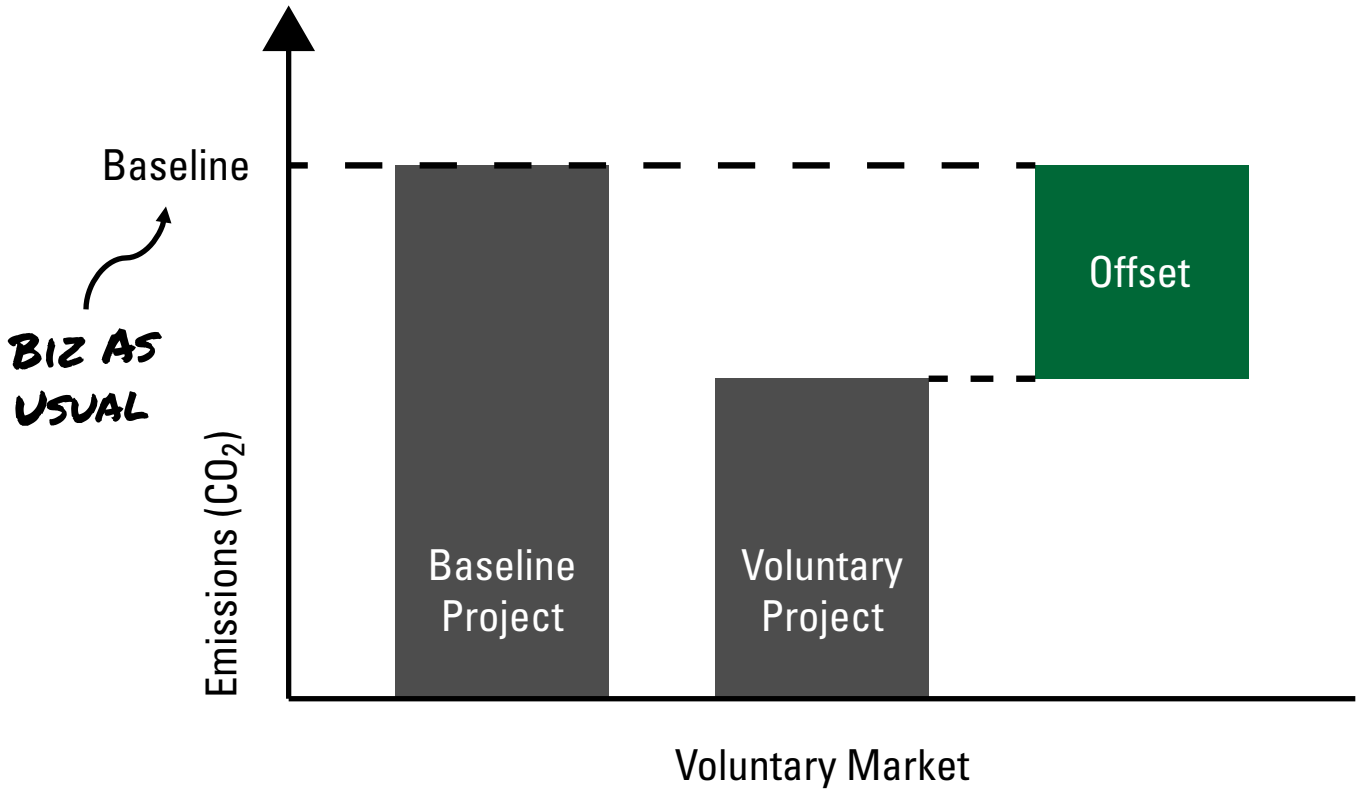
Two ways to verify emission reductions:

- Project Baselines
- Performance Benchmarks

Baseline Method

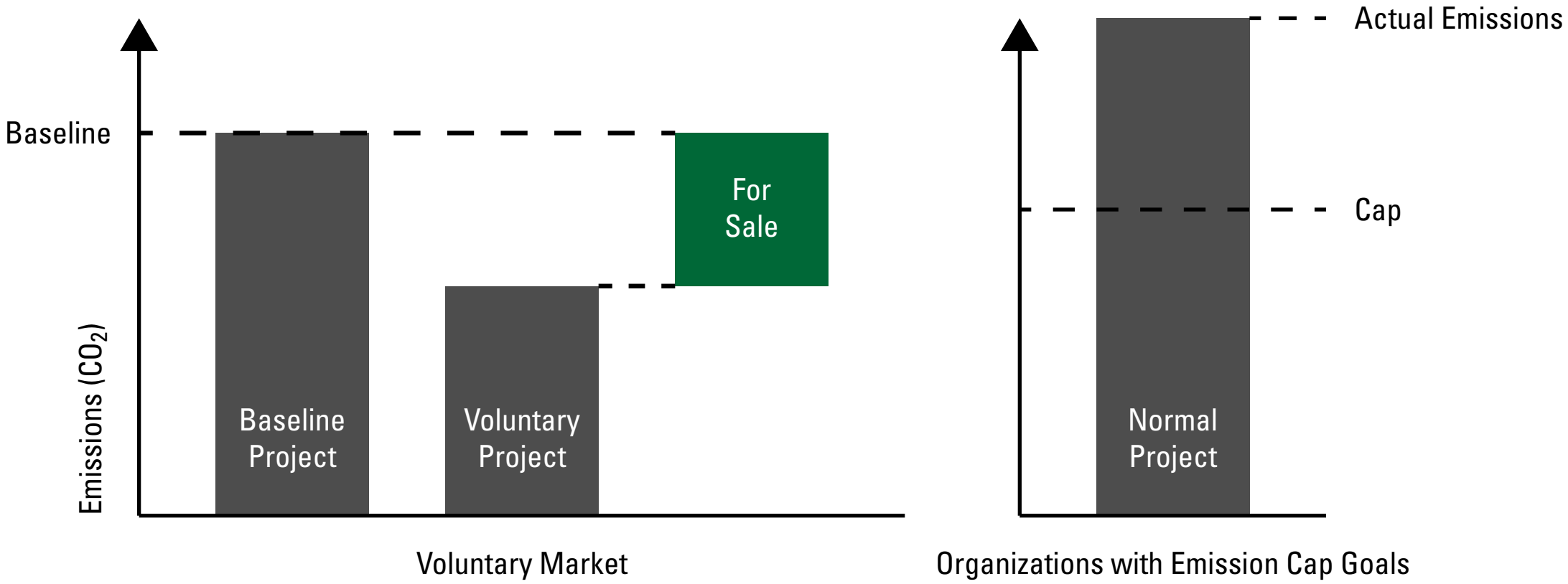


Baseline Method



OFFSETS = "ADDITIONAL" REDUCTIONS
WHO WILL BUY THEM?

Baseline Method



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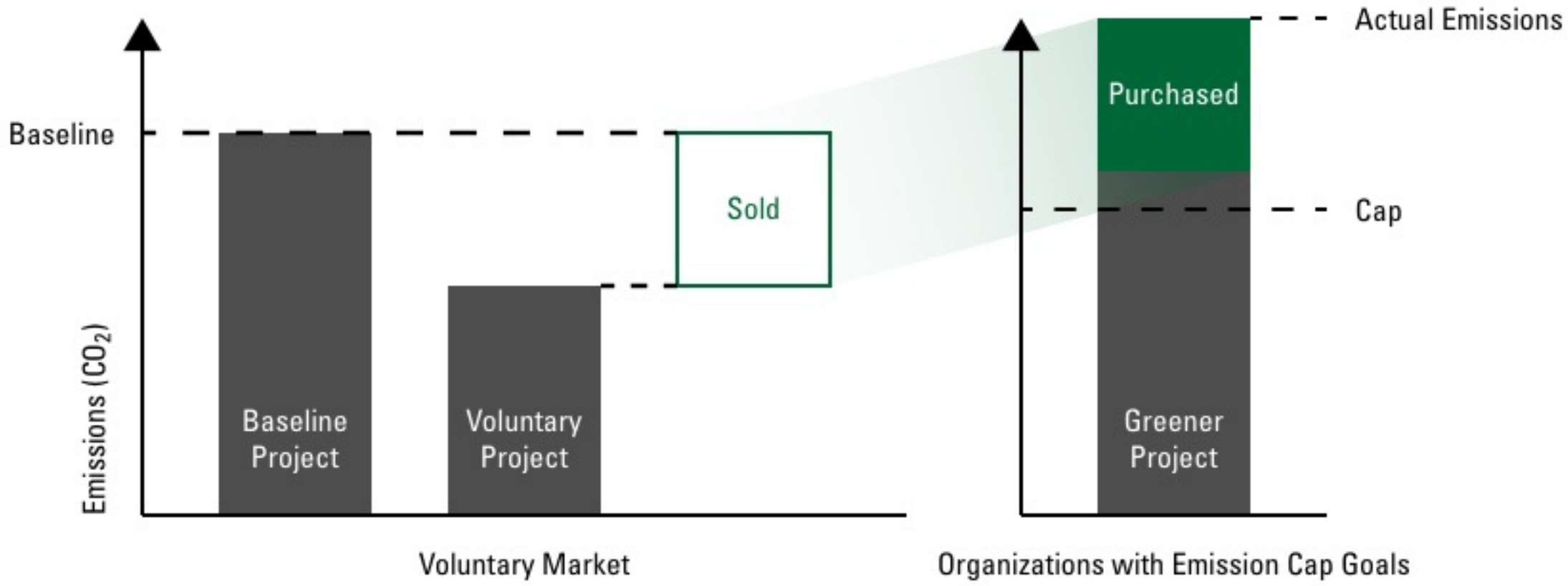
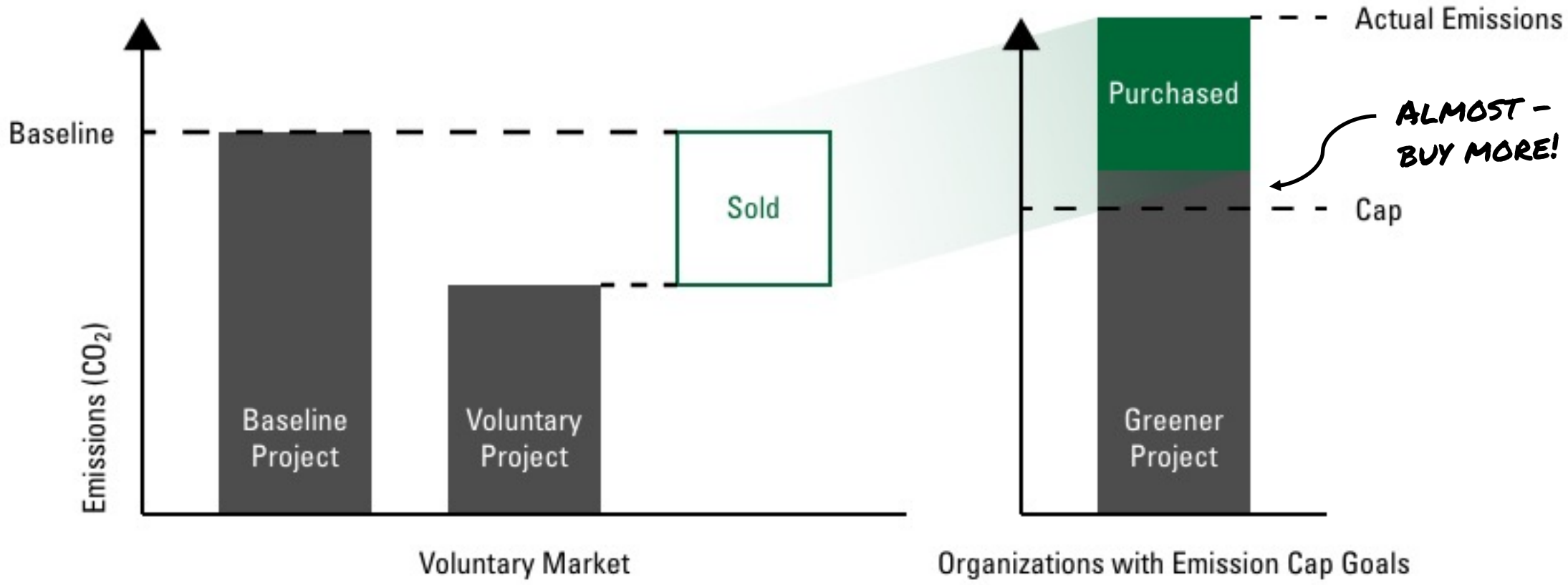


Baseline Method

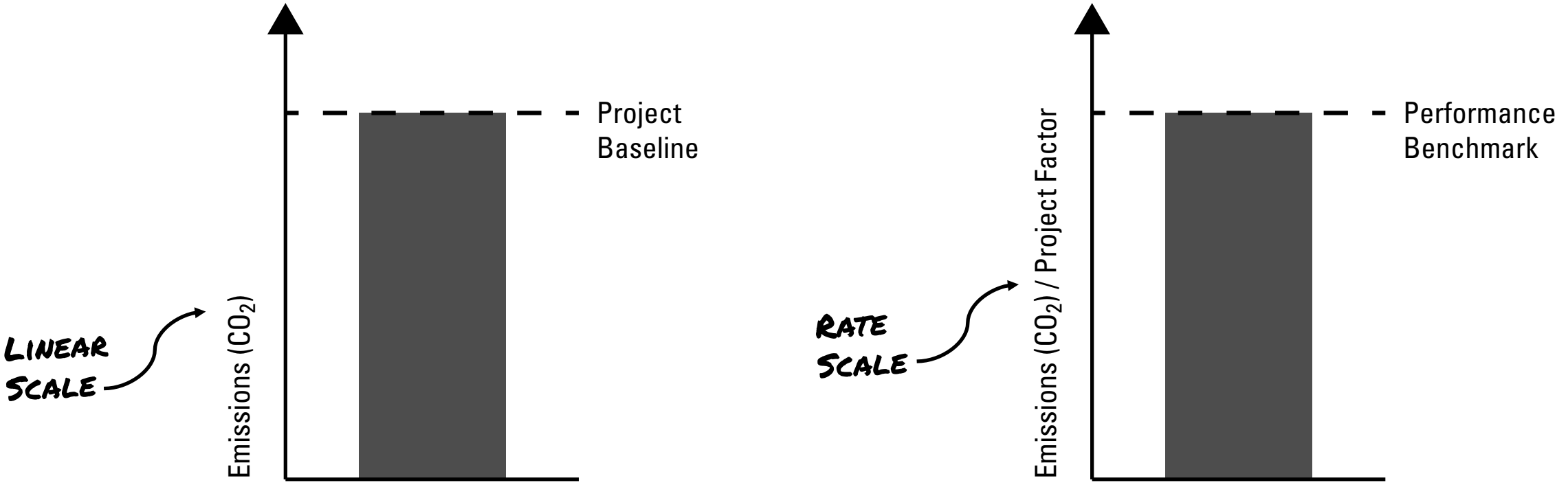


Many projects are different sizes but technically similar.

How can we capitalize on their similarities?

We can compare different size projects with a rate – a *performance benchmark*: CO_2 / Project Factor

Project Baseline vs Performance Benchmark



Project Baseline vs Performance Benchmark

Project Baseline

Calculate CO_2 emissions for *two* scenarios and their difference

Performance Benchmark

Calculate CO_2 for *one* scenario, and compare it to a benchmark rate: CO_2 / project factor

Project Baseline vs Performance Benchmark

Project Baseline

- For unique projects
- Not scalable
- Expensive to justify the business as usual case

Performance Benchmark

- For similar projects
- Scalable
- Predefined business as usual case: CO_2 / project factor

4/5: PAVEMENT PERFORMANCE BENCHMARK

HMA Study

16

HMA Plants
(Maryland)

16

Placement Projects
(Maryland and Virginia)

HMA Emission Categories

Raw Materials
Mix Plant
Hauling
\+ Installation

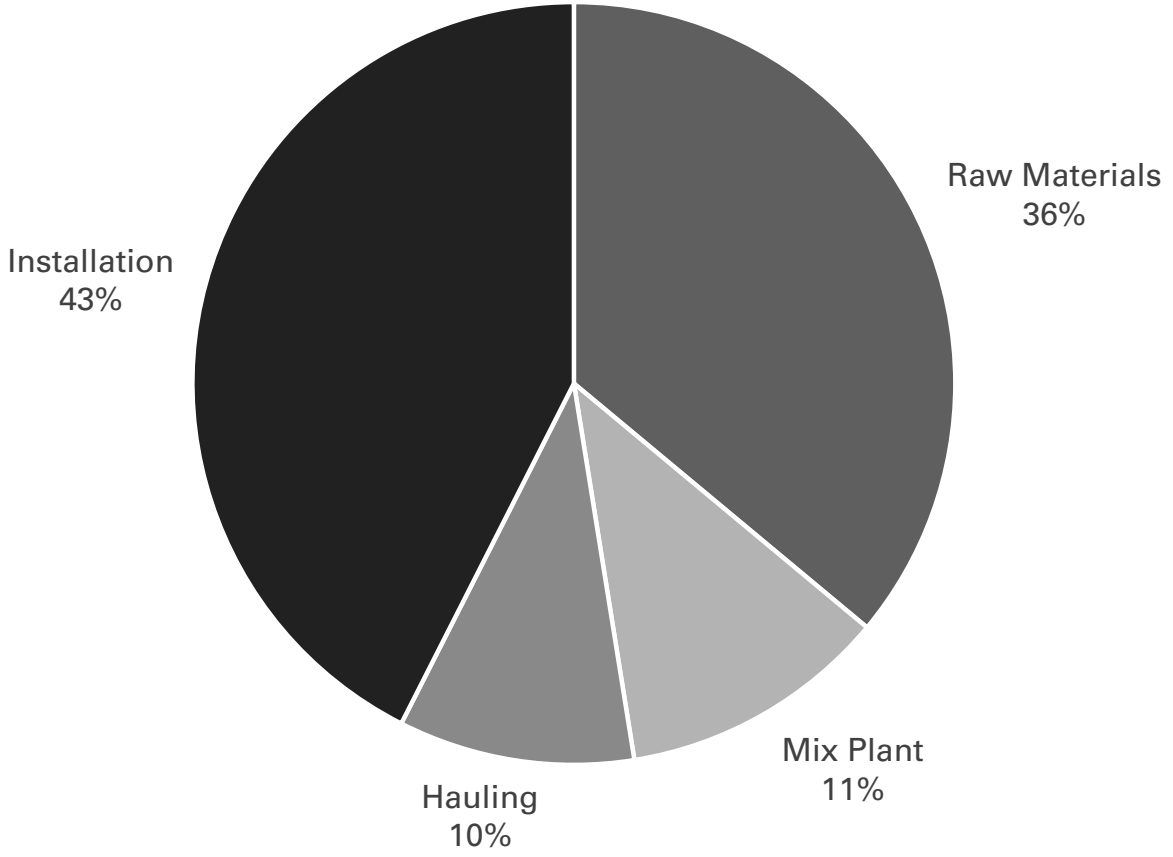
Project Emissions

QUARRYING + PROCESSING

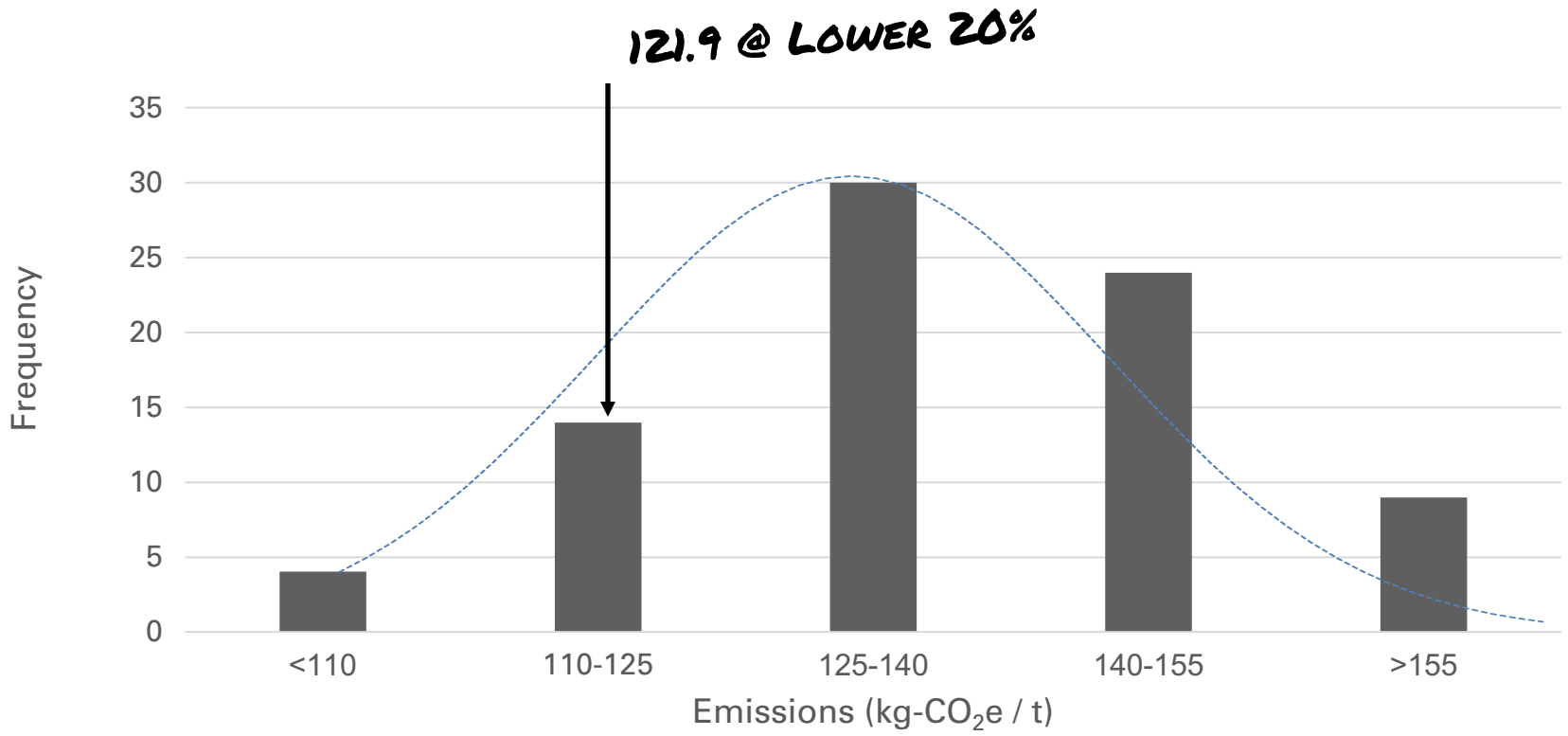
SOURCE TO PLANT + PLANT TO JOB SITE

HMA Emission Categories

Category	Emissions ($kg\text{-}CO_2e/t$)
Raw Materials	54
Mix Plant	17
Hauling	15
Installation	64



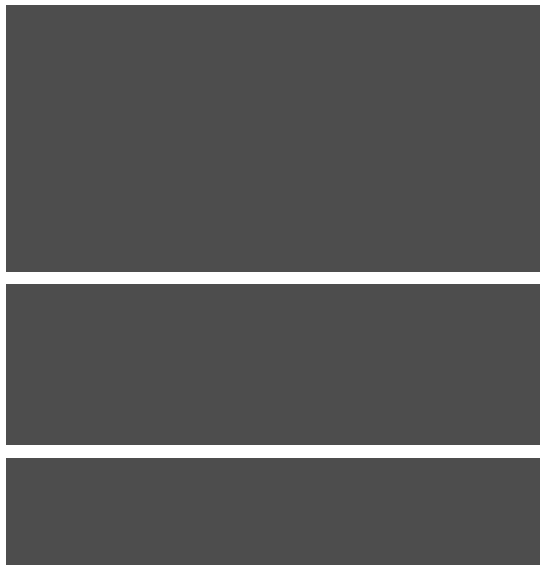
HMA Emission Distribution



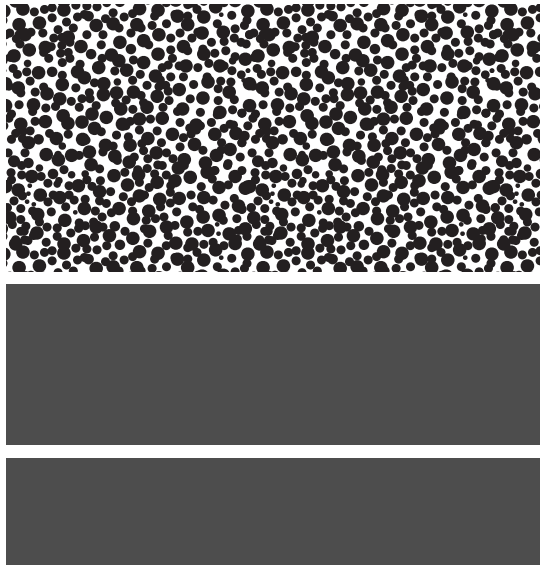
HMA Performance Benchmark

Project Type	Hauling Distance (miles)	Benchmark (kg-CO_2e/t)
Parking Lot	≤ 40	121.9
Parking Lot	> 40	142.4
Road	Any	102.9

Structural Performance Adjustment



Traditional Project



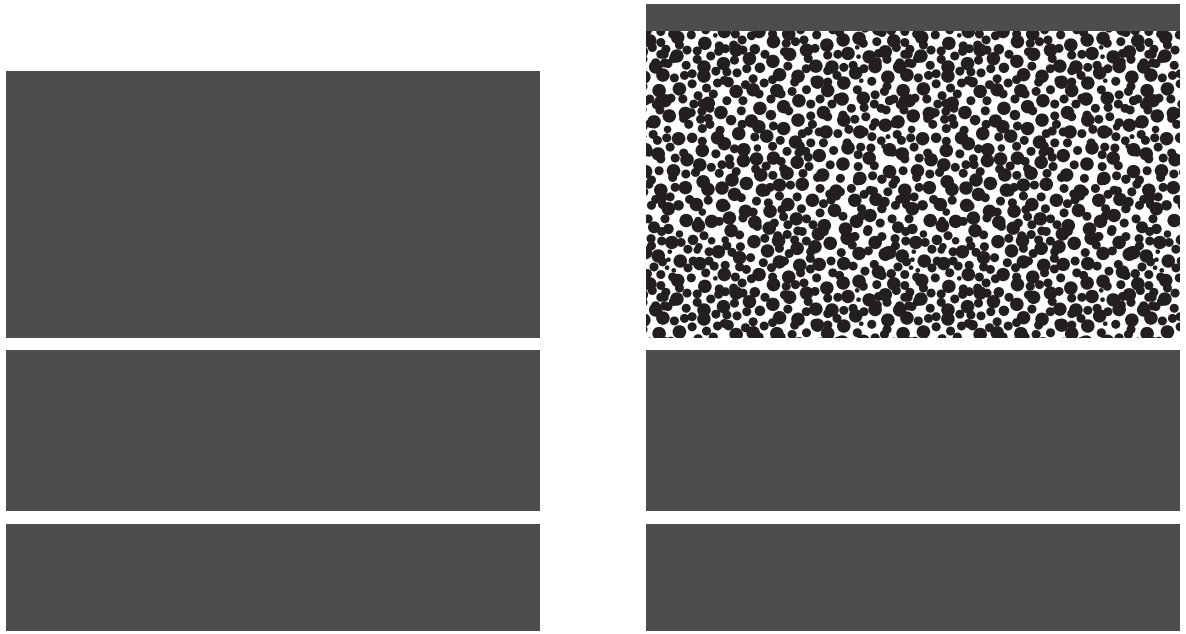
Offset Project

Directly replacing HMA with all FSB lowers structural performance and provides a poor surface layer.

Same Granular Base

Same Sub-Base

Structural Performance Adjustment



Traditional Project

Offset Project

Replacing HMA with an FSB layer and a small HMA surface layer yields an equal structural performace that is 2% heavier and 25% thicker.

Same Granular Base

Same Sub-Base

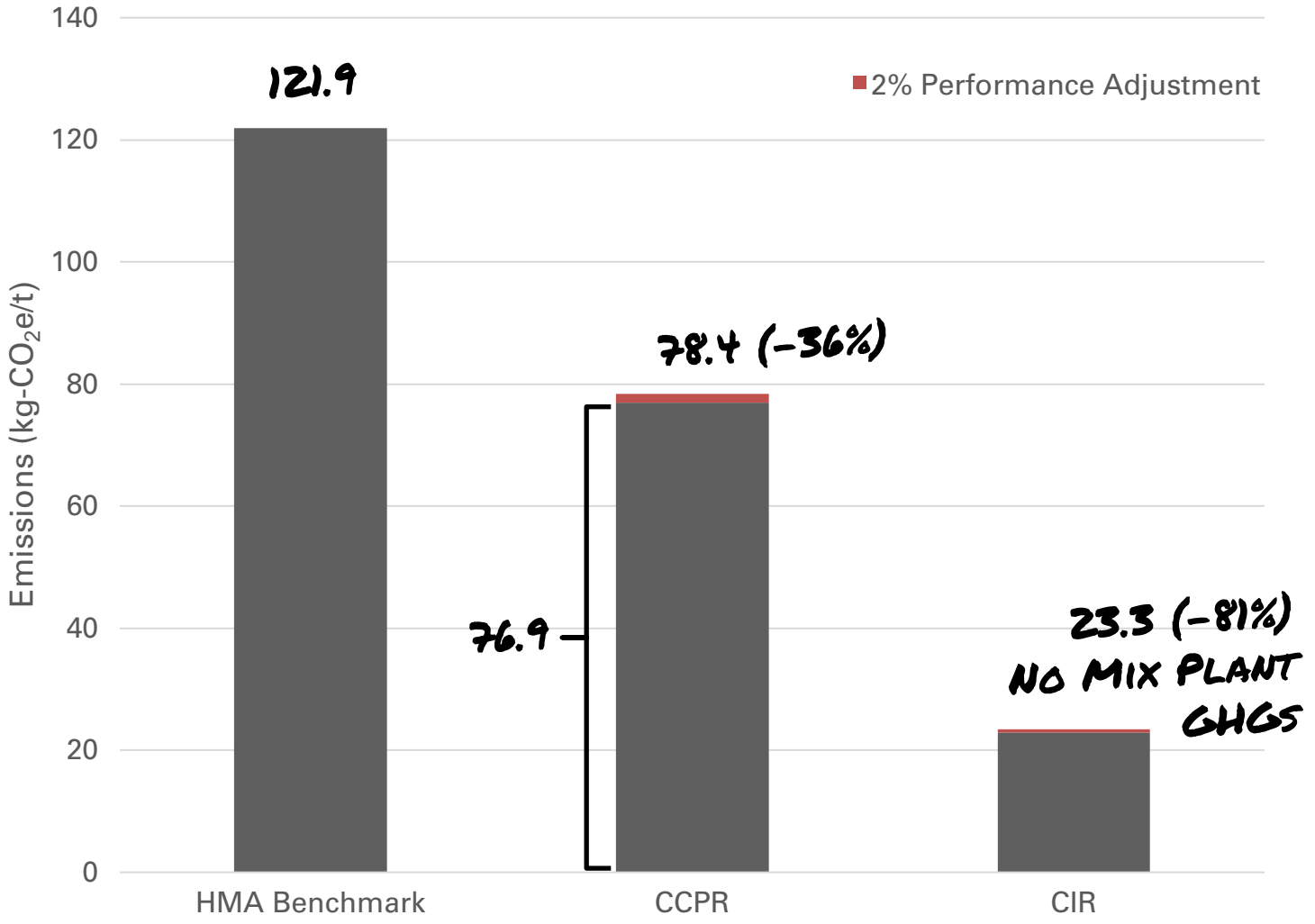
FSB Emission Reductions

With the 2% structural performance adjustment:

HMA benchmark
121.9 kg-CO_2e/t:

Cold Central Plant Recycling (CPPR)
78.4 kg-CO_2e/t
36% Reduction

Cold In-Place Recycling (CIR)
23.3 kg-CO_2e/t
81% Reduction



CCPR Total Savings

material savings
\+ offset savings

= total ($/t-material)

CCPR Material Savings (Installed)

HMA	110	
FSB	90	
Savings	20	($/t-material)

110
- 90
= 20

CCPR Offset Savings

HMA Benchmark	121.9
Adjusted FSB	78.4
Savings	43.5 kg-CO_2e/t-material

EMISSION SAVINGS
121.9 – (76.9 * 1.02) = 43.5

At a market rate of $9.30 / 1,000 kg-$CO_2$e:
Savings: 0.4 ($/t-material)

COST SAVINGS
43.5*9.3/1000 = 0.4

CCPR Total Savings

material savings
\+ offset savings

= total ($/t-material)

CCPR Total Savings

$20/t material savings

\+ $0.4/t offset savings

= $20.4/t ($/t material)

CCPR Contractor Profits

$0.4 offset savings < $20 material savings

CCPR Contractor Profits

$0.4 offset savings < $20 material savings

If a contractor

1. Purchases FSB at $25/t (FOB, material only)
2. Sells it for a 10% profit margin ($2.5)
3. Carbon offset savings ($0.4/t) raise profits 16%

5/5: CONCLUSIONS

Conclusions

- Performance benchmarks developed in this study may be used with or without FSB
- FSB projects generate ~43.5 kg-CO_2e/t carbon offset credits
- Replacing HMA with FSB yields ~$20.4/t in savings
- $0.4/t in offset credits can increase contractor material profits (~16%)

What's Next

- Approve methods
- Launch app

My Projects Logout

Get Paid

It's like you just planted a small forest, and we want to reward you.

Payback Estimate

$18,008

Carbon Reduction
15,591,377 lb CO_2

Ready Projects

Another project
$32 for 28,003 lb CO_2

Interstate 64
$17,976 for 15,563,375 lb CO_2

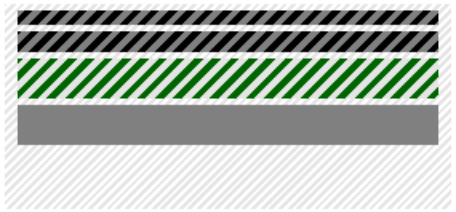
Terms and Conditions

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore

Project Logout

Areas

All Traffic - Greenified
199,372.8 yd^2



2 in HMA (2893), SN 0.88
2.5 in HMA (2893), SN 1.1
6 in FSB (2901), SN 1.92
6 in Cement Treated Base (CTB), SN 1.2

New Layer

Thickness: 16.5 in
Impact: 17,484 tons CO_2
Structural Number: 5.1
Green Mix: Yes

Design B

Interstate 64 > Design B > Area One

Edit Layer 3

Summary
SN 1.92
58,317 tons of mix
4,217 tons CO_2

Layer Position
3

Thickness
6 in

Mix Plant to Job Site Distance
3.5 miles

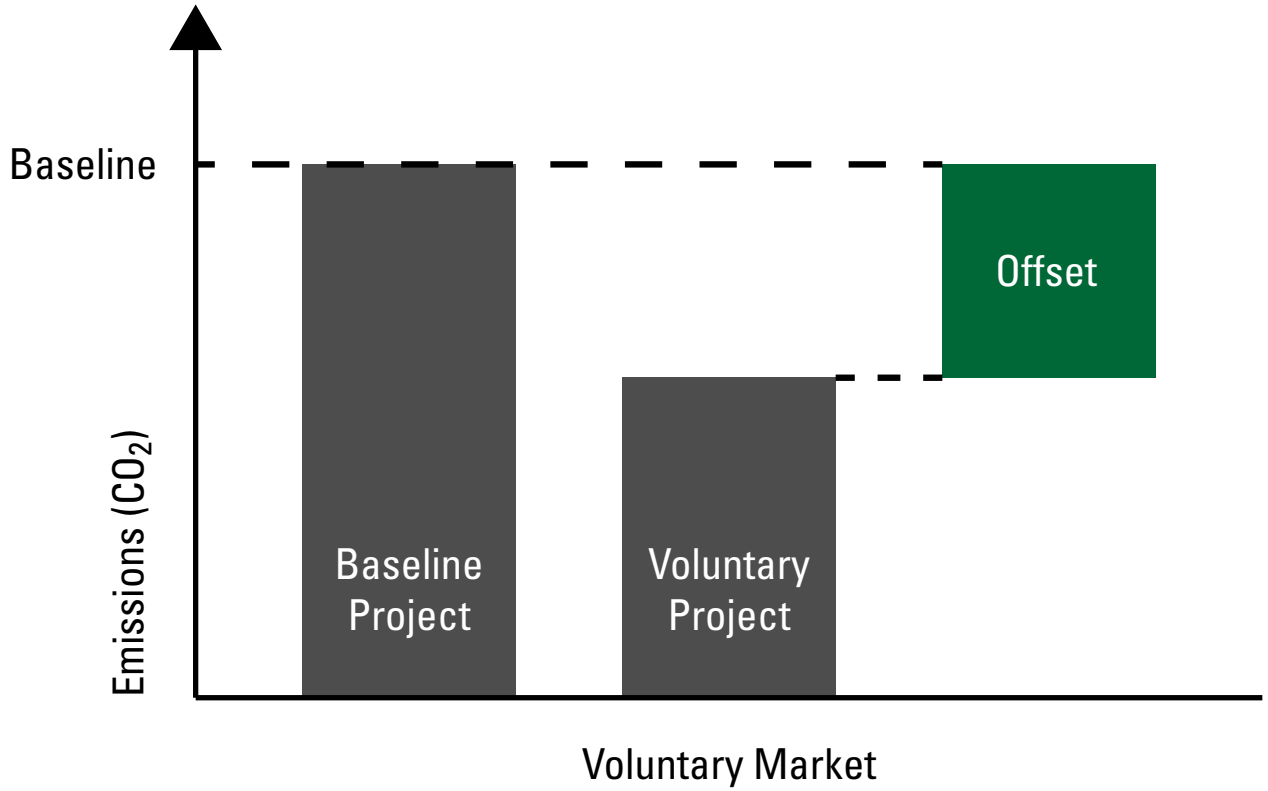
Mix Materials

QUESTIONS?

These didn't make my presentation, but might be helpful in answering your questions

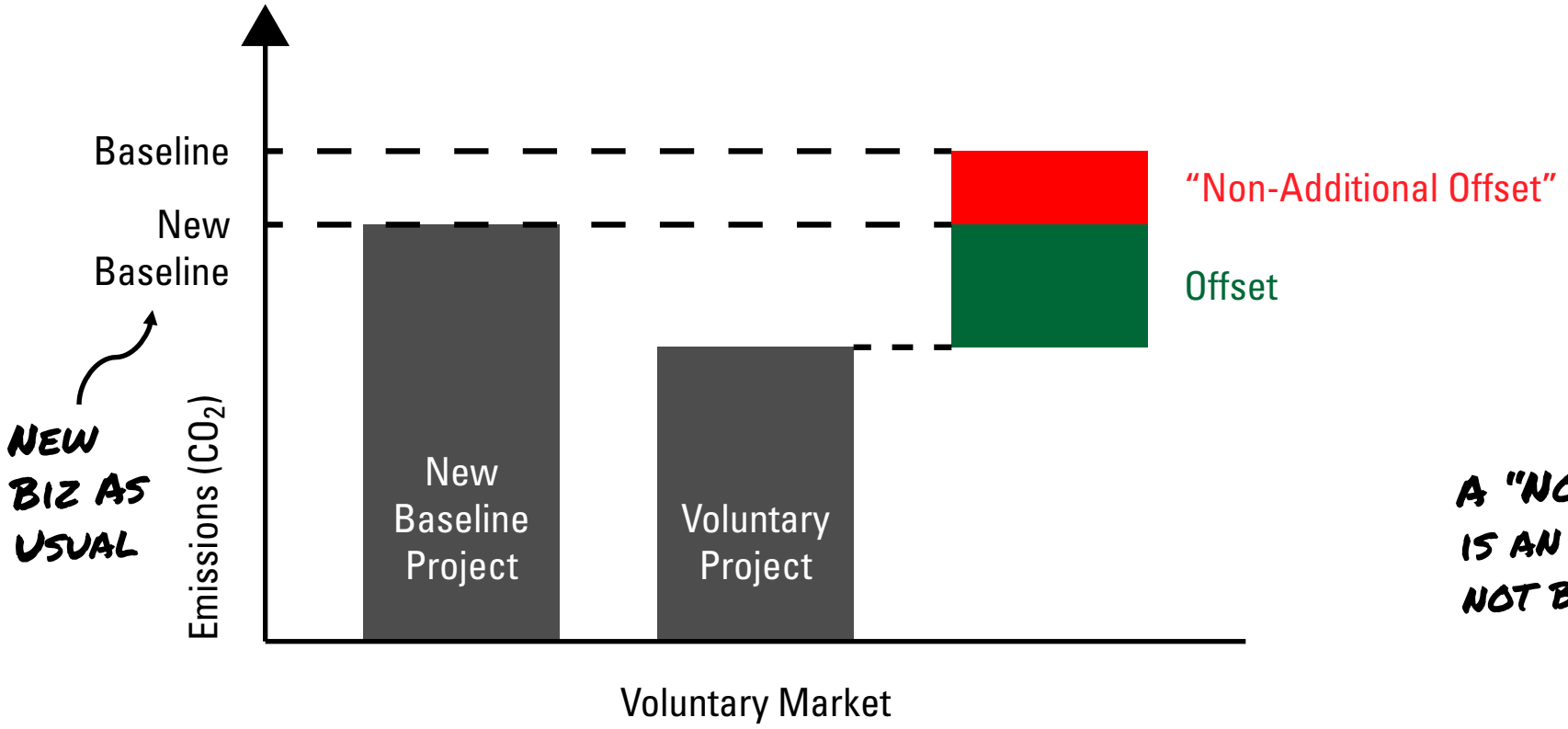
BACK UP SLIDES

Non-Additionality



WHAT IF BASELINE PROJECT EMISSIONS DECREASE OR HAVE BEEN OVERESTIMATED?

Non-Additionality



A "NON-ADDITIONAL" OFFSET IS AN OFFSET THAT SHOULD NOT BE AWARDED.

HMA Greenhouse Gases and Air Pollutants

Carbon Dioxide (CO_2)
Sulfur dioxide (SO_2)
Nitrogen oxide (NO_x)
Carbon monoxide (CO)
Volatile organic compounds (VOC)
Volatile hazardous air pollutant (HAP)

EPA 2009