Better Buildings®
SUMMIT

AUGUST 21-23, 2018 • CLEVELAND, OHIO

Metrics and Big Data

ALTRAMESE ROBERTS-TOMPKINS | *SENIOR ENGINEER*

Happy Target Setting

May the metrics be forever in your favor

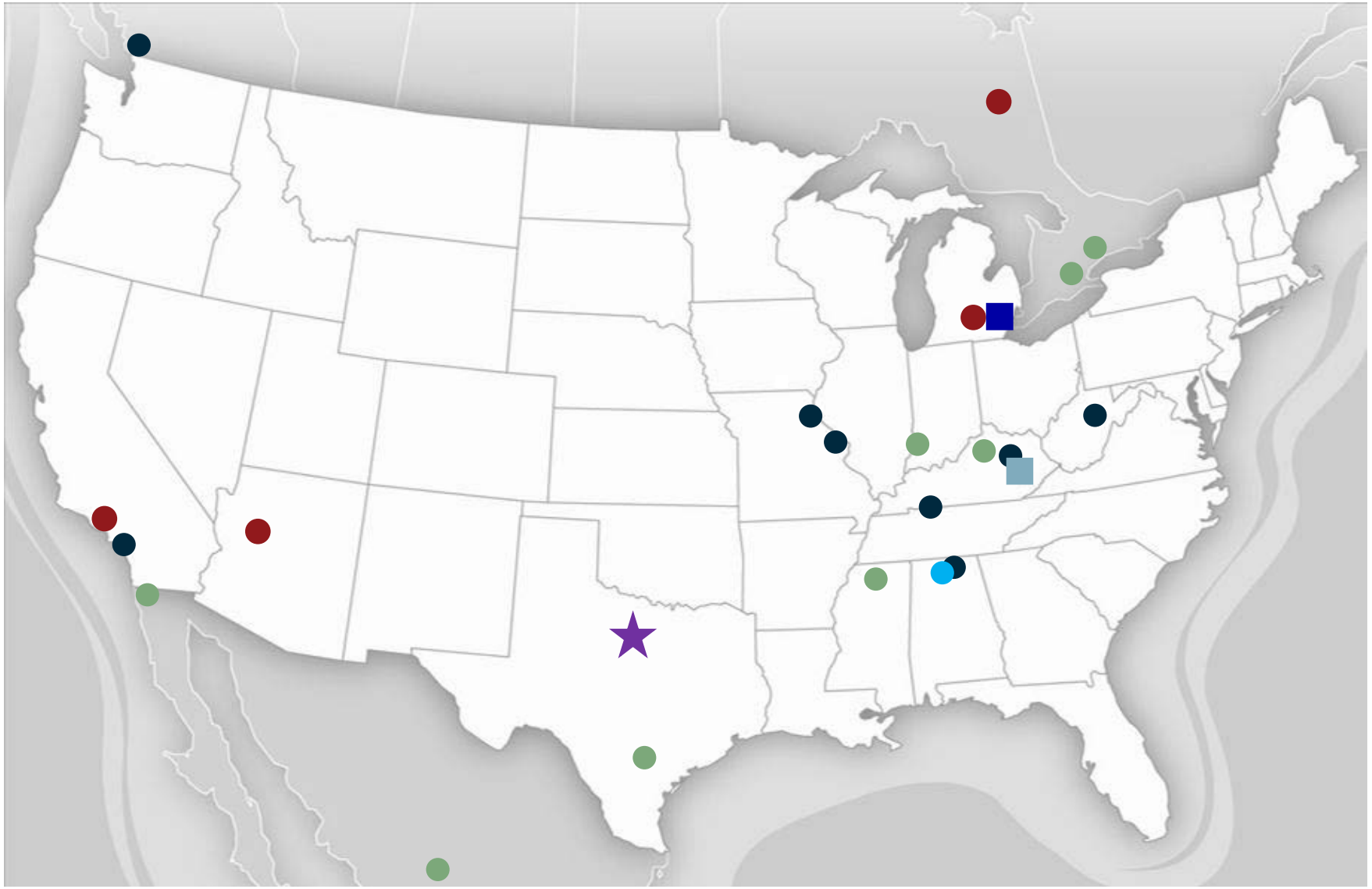
TOYOTA

Energy Exchange | Better Buildings SUMMIT

Background

Operations

TOYOTA NORTH AMERICA OPERATIONS



- Vehicle Assembly (8)
- Unit Plant (8)
- Research & Development (4)
- Manufacturing Purchasing
- Production Engineering
  Georgetown, KY
- Corporate Headquarters
  Plano, TX
- Toyota & Mazda Joint Venture
  Huntsville, AL

29 Million Sq.Ft.

Strategy

Plan for Action

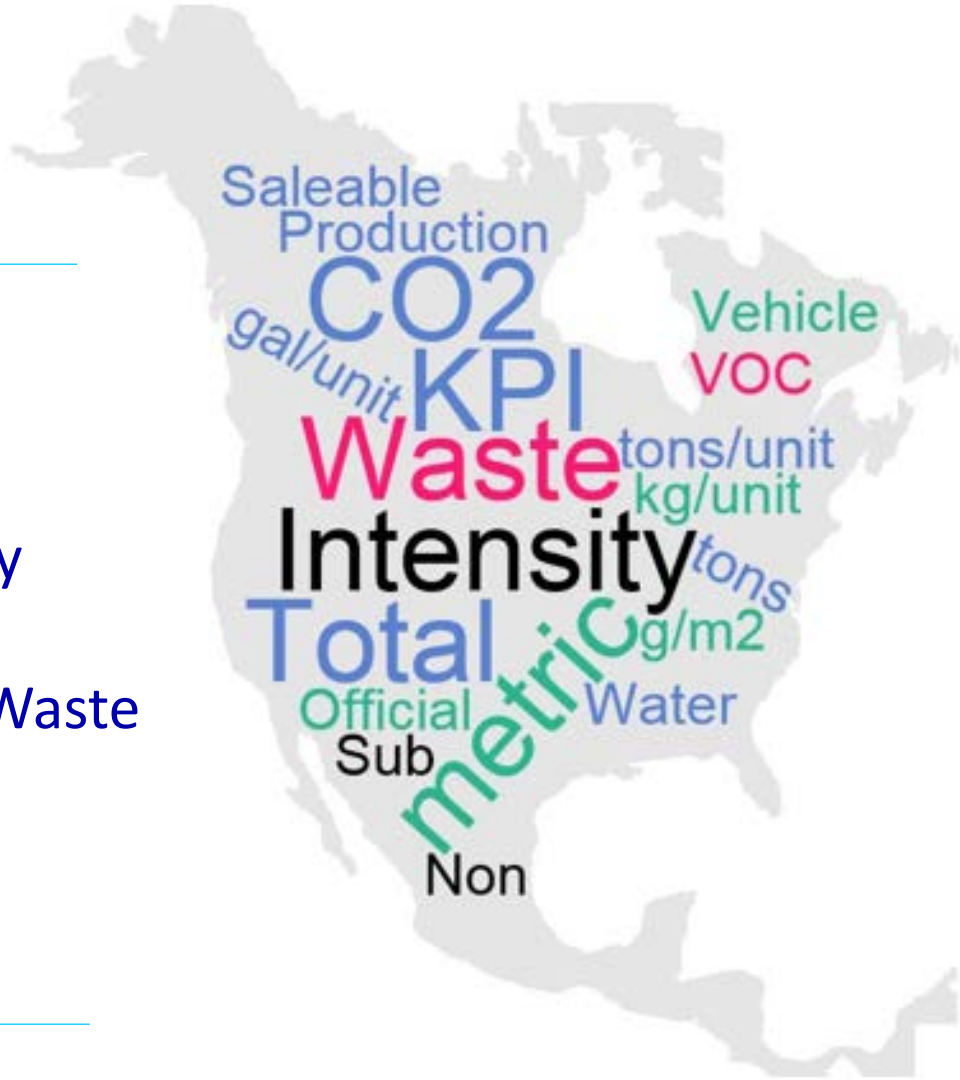
Facilities Metrics

Metrics & Measures	KPIs
• Unplanned Failures • Repair Time (hours)	MTTR (hours / # of failures)
• In House PMs Planned • In House PMs Completed	PM Completion Rate (%)
• Natural Gas Purchase Cost ($) • Electric Purchased Cost ($)	Total Energy Cost ($)

Quality	Production	Cost

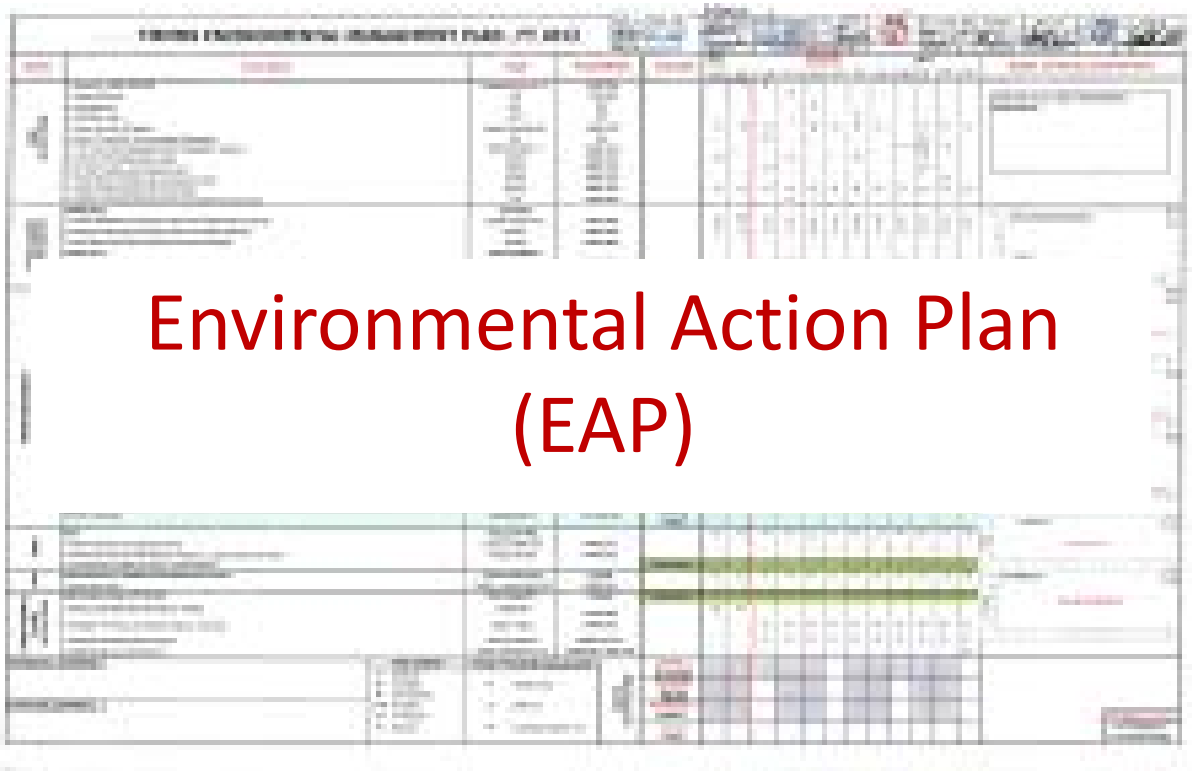
Environmental Metrics

Metrics & Measures	KPIs
• Electric Consumed (kWh) • Natural Gas Consumed (MMBtu)	CO_2 Absolute (MT)
• Water Consumed (gal) • Total Production (unit)	Water Intensity (gal / unit)
• Non Saleable Waste (kg)	Non Saleable Waste (kg / unit)
• Volatile Organic Compounds (VOCs) (g/m^2)	VOCs (g / m^2)



EEMS	Compliance	Performance	Risk

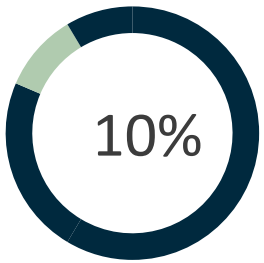
5 Year Strategy



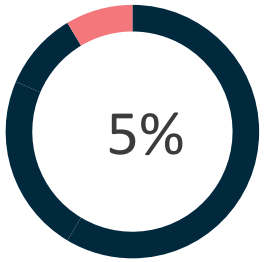
Environmental Action Plan (EAP)

Activities planned to achieve targets

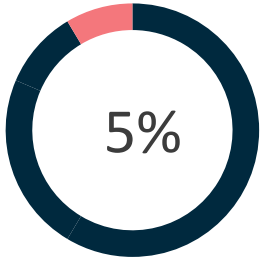
% Baseline reduction by 5th year



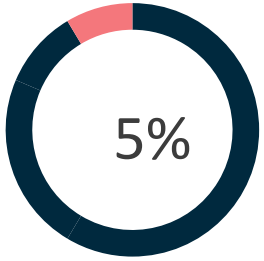
CO_2:
2% Per Year



Water:
1% Per Year



VOC:
1% Per Year



Waste:
1% Per Year

Annual Planning

Yearly Checkpoint

Preparation

1. Preliminary
2. Data Gathering
3. Linear Regression
4. Project Impacts
5. Target Templates

Target Setting Process

Preliminary

1 Prelim | 2 Data | 3 Analytics | 4 Impacts | 5 Templates

Target Setting

No.	Milestone	Start	End	Status (% Complete)				September				October				November				December				January			
				25	50	75	100	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4
1	Determine preliminary KPI metrics for setting targets and create target setting schedule	09/03	09/05																								
2	Run regressions and prepare NAMC target files	09/03	09/05																								
3	Transmit preliminary targets and draft schedule to NAMCs before conference	09/06	09/18																								
4	Plant and Environmental Engineering Conference	10/1	10/1																								
5	Gather information and update target files (i.e., IE Projects, 2050 Projects, Renewables)	10/23	10/25																								
6	Kickoff meetings to discuss target files and request NAMC Kaizens and Projects as well as review production projections	10/29	11/09																								
7	Analysis and Environmetal Management Plan (EMP) template preparation	11/12	11/16																								
8	NAMC response, negotiation and Nemawashi (consensus building) between TMNA and NAMCs with signoff on final EMPs	12/03	01/18																								
9	Confirmation of all details and signoff on final EMPs	01/18	01/31																								
10	Target setting process complete	01/31	01/31																								

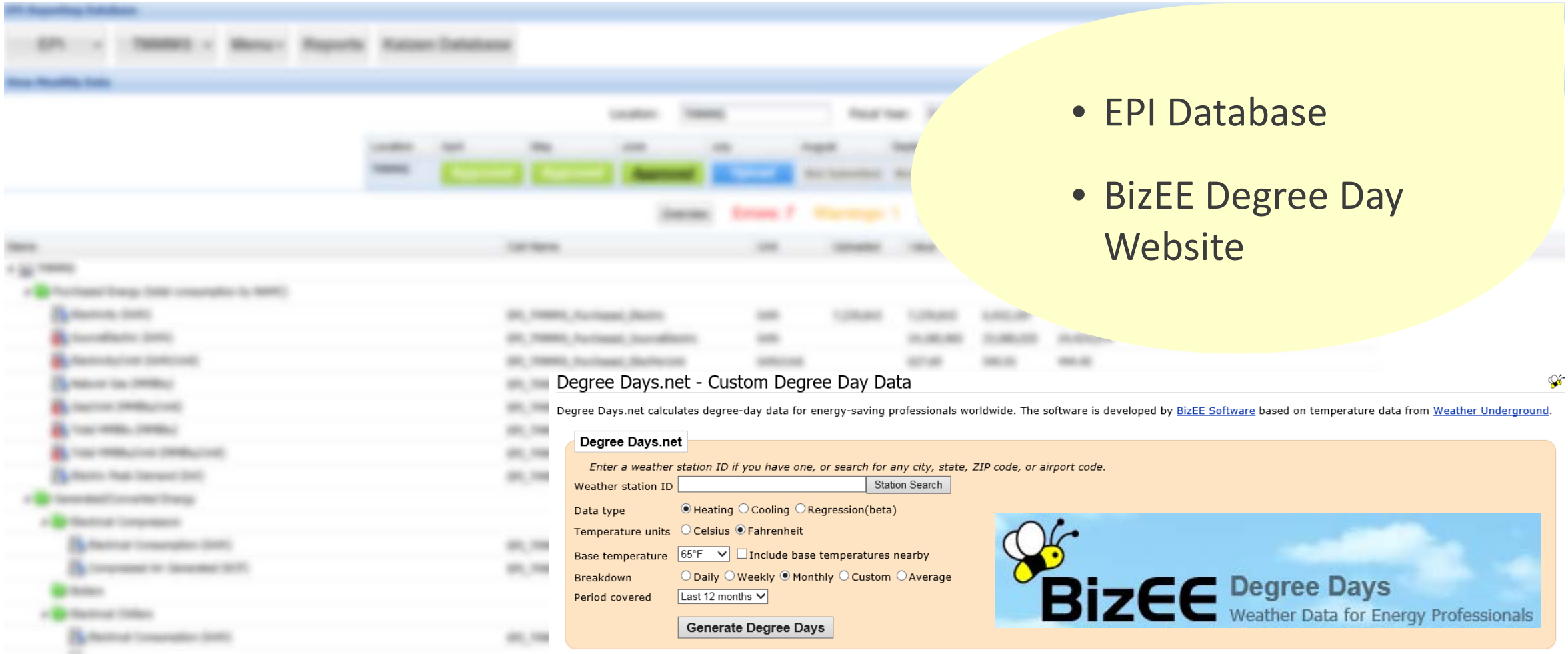
EXAMPLE SCHEDULE

- Confirm metrics
- Develop schedule

Data Gathering

1 Prelim | 2 Data | 3 Analytics | 4 Impacts | 5 Templates

Target Setting



- EPI Database
- BizEE Degree Day Website

Degree Days.net - Custom Degree Day Data

Degree Days.net calculates degree-day data for energy-saving professionals worldwide. The software is developed by BizEE Software based on temperature data from Weather Underground.

Degree Days.net

Enter a weather station ID if you have one, or search for any city, state, ZIP code, or airport code.

Weather station ID [ ] Station Search

Data type (•) Heating ( ) Cooling ( ) Regression(beta)

Temperature units ( ) Celsius (•) Fahrenheit

Base temperature 65°F [ ] Include base temperatures nearby

Breakdown ( ) Daily ( ) Weekly (•) Monthly ( ) Custom ( ) Average

Period covered Last 12 months

Generate Degree Days

BizEE Degree Days
Weather Data for Energy Professionals

Regression Analysis

1 Prelim | 2 Data | 3 Analytics | 4 Impacts | 5 Templates

Target Setting

Actuals thru Dec. 2017 + FY18/FY19 Projected Production

Actual | Forecast

FY	Month	ELE (kWh)	Vehicles	CDD	3YR CDD
	Jan-17	19,567,901	37,012	0	0
	Feb-17	17,996,885	34,874	5	2
	Mar-17	20,246,456	40,718	10	8
FY18	Apr-17	16,928,296	26,484	78	54
	May-17	21,302,846	38,015	153	159
	Jun-17	23,389,839	38,889	305	342
	Jul-17	22,190,833	24,026	365	375
	Aug-17	24,789,006	38,961	232	296
	Sep-17	21,970,158	34,982	197	211
	Oct-17	20,531,234	37,347	83	75
	Nov-17	17,960,582	32,880	6	11
	Dec-17	17,476,206	28,253	0	1
	Jan-18	0	37,402	0	0
	Feb-18	0	34,285	0	0
	Mar-18	0	37,747	0	0
FY19	Apr-18		37,434		
	May-18		39,061		
	Jun-18		35,652		
	Jul-18		26,763		
	Aug-18		40,785		
	Sep-18		32,300		
	Oct-18		37,492		
	Nov-18		32,408		
	Dec-18		24,485		
	Jan-19		38,054		
	Feb-19		35,680		
	Mar-19		35,040		

FY	Month	NG (MMBtu)	Vehicles	HDD	3YR HDD
	Jan-17	148,818	37,012	855	965
	Feb-17	121,952	34,874	575	820
	Mar-17	124,659	40,718	582	574
FY18	Apr-17	53,442	26,484	207	256
	May-17	63,136	38,015	130	122
	Jun-17	51,911	38,889	29	17
	Jul-17	40,838	24,026	6	4
	Aug-17	50,124	38,961	33	22
	Sep-17	56,984	34,982	82	74
	Oct-17	83,790	37,347	276	253
	Nov-17	112,802	32,880	591	541
	Dec-17	149,351	28,253	990	882
	Jan-18	0	37,402	1,166	1,024
	Feb-18	0	34,285	0	0
	Mar-18	0	37,747	0	0
FY19	Apr-18		37,434		
	May-18		39,061		
	Jun-18		35,652		
	Jul-18		26,763		
	Aug-18		40,785		
	Sep-18		32,300		
	Oct-18		37,492		
	Nov-18		32,408		
	Dec-18		24,485		
	Jan-19		38,054		
	Feb-19		35,680		
	Mar-19		35,040		

Variables

- Electricity (kWh)
- Natura Gas (MMBtu)
- Water (gal)
- CDD (cooling degree days)
- HDD (heating degree days)
- Production (units)

Regression Analysis

NG (MMBtu) Regression

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99336664
R Square	0.98677727
Adjusted R Square	0.98383889
Standard Error	5189.11599
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	18085371444	9042685722	335.823188	3.5152E-09	1.00000
Residual	9	242342323.2	26926924.8			
Total	11	18327713767				

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	
Baseload	Intercept	3872.89012	10278.20273	0.376806161	0.71504822	-19378.0198	27123.8	-19378.0198	27123.8	0.28495
Production	X Variable 1	1.21203434	0.290109445	4.177852073	0.00238367	0.55576119	1.8683075	0.55576119	1.8683075	0.99762
HDD	X Variable 2	117.461625	4.567872474	25.71473386	9.7997E-10	107.12838	127.79487	107.12838	127.79487	1.00000

ELE (kWh) Regression

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.95888739
R Square	0.91946503
Adjusted R Square	0.90156837
Standard Error	778525.191
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	6.22786E+13	3.11393E+13	51.3763472	1.1938E-05	0.99999
Residual	9	5.45491E+12	6.06101E+11			
Total	11	6.77335E+13				

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	
Baseload	Intercept	9763704.33	1566371.835	6.233324748	0.00015265	6220325.06	13307083.6	6220325.06	13307083.6	0.99985
Production	X Variable 1	250.954427	43.85044406	5.722962049	0.00028588	151.757831	350.151023	151.757831	350.151023	0.99971
CDD	X Variable 2	16515.723	1829.825343	9.025846668	8.34E-06	12376.3705	20655.0755	12376.3705	20655.0755	0.99999

- Perform linear regression
- Review summary output

Regression Analysis

Use variables from regression to model ELE, NG and Water

Regression Models

ELE and NG Variables		
ELE Model		
Base	9,763,704	kWh/month
Production	251	kWh/vehicle
CDD	16,516	kWh/CDD
NG Model		
Base	3,873	MMBtu/month
Production	1	MMBtu/vehicle
HDD	117	MMBtu/HDD

Variables Converted (MT)		
FY18 Base	7,305	MT/month
FY19 Base	5,711	MT/month

FY18
ELE (lbs/kWh)
NG (lbs/MMBtu) **117**

FY19
ELE (lbs/kWh)
NG (lbs/MMBtu) **117**

FY	Month	Month	CDD	HDD	3YR CDD	3YR HDD
	Apr-16	19,294,986	46	342	46	274
	May-16	19,967,152	104	163	182	114
	Jun-16	23,656,342	375	8	360	10
	Jul-16	22,494,725	352	2	348	14
	Aug-16	27,748,058	362	5	337	14
	Sep-16	23,090,819	233	53	209	82
FY17						

FY18

Month	ELE (kWh)	NG (MMBtu)	Total MT	MT/veh	Prod	CDD	HD
Apr-17	16,928,296	53,442	13,426	0.51	26,484	78	
May-17	21,302,846	63,136	16,677	0.44	38,015	153	
Jun-17	23,389,839	51,911	17,387	0.45	38,889	305	
Jul-17	22,190,833	40,838	16,050	0.67	24,026	365	
Aug-17	24,789,006	50,124	18,168	0.47	38,961	232	
Sep-17	21,970,158	56,984	16,768	0.48	34,982	197	
Oct-17	20,531,234	83,790	17,291	0.46	37,347	83	
Nov-17	17,960,582	112,802	17,222	0.52	32,880	6	
Dec-17	17,476,206	149,351	18,858	0.67	28,253	0	
Jan-18	0	0	25,054	0.67	37,402	0	
Feb-18	0	0	23,027	0.67	34,285	2	
Mar-18	0	0	22,376	0.59	37,747	8	
			222,305	**0.54**	**409,271**	**1,429**	
			87,657	7,305			

FY19

Month	ELE (kWh)	NG (MMBtu)	Total MT	MT/veh	Prod	CDD	HD
Apr-18	=$D$4+$D$5*O21+$D$6*P21		15,515	0.41	37,434	54	
May-18	22,186,124	65,527	15,988	0.41	39,061	159	

Project Impacts

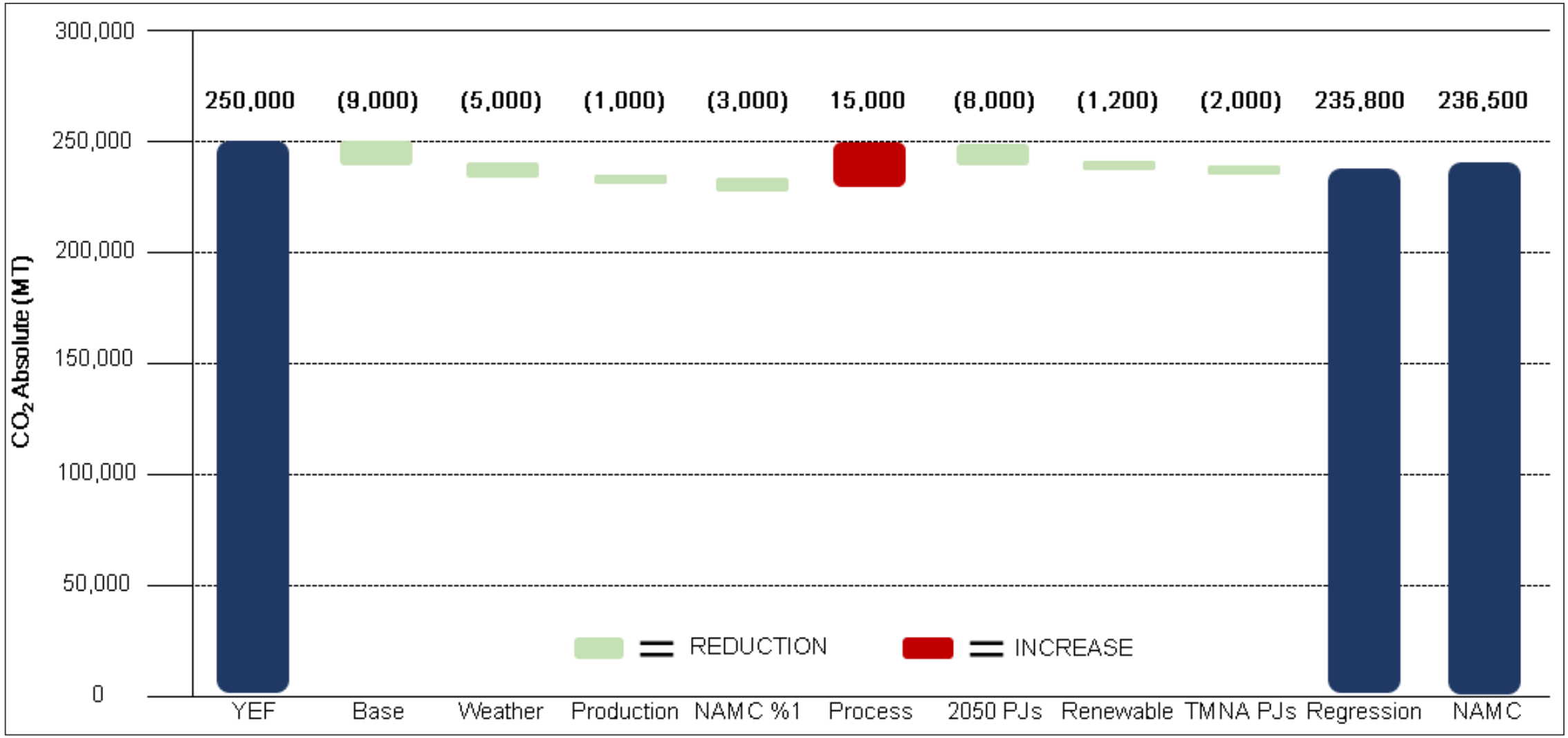
Target table and project impact

Total CO2 Absolute Table

Month	Previous FY	Forecasted FY										
		Base Usage	Weather Impact	Production Impact	NAMC Kaizens	Process Changes	PE Technology	2050 Projects	Renewable	TMNA Projects	Total Monthly	Total Cumulative
April	13,426	5,711	2,099	7,705	(134)	3,540	0	0	0	0	18,921	18,921
May	16,677	5,711	2,237	8,040	(167)	3,548	0	0	0	0	19,369	38,290
June	17,387	5,711	3,295	7,338	(174)	3,764	0	0	0	0	19,935	58,225
July	16,050	5,711	3,512	5,509	(160)	4,127	0	(77)	0	0	18,621	76,846
August	18,168	5,711	2,895	8,395	(182)	4,815	0	(77)	0	0	21,557	98,404
September	16,768	5,711	2,421	6,648	(168)	4,081	0	(77)	0	0	18,617	117,021
October	17,291	5,711	2,278	7,717	(173)	3,520	0	(77)	0	0	18,976	135,996
November	17,222	5,711	3,471	6,671	(172)	4,172	0	(77)	0	0	19,776	155,772
December	18,858	5,711	5,503	5,040	(189)	4,029	0	(77)	0	0	20,017	175,789
January	25,054	5,711	6,014	7,833	(251)	3,244	0	(591)	0	0	21,960	197,749
February	23,027	5,711	5,130	7,344	(230)	3,244	0	(591)	0	0	20,608	218,358
March	22,376	5,711	3,652	7,212	(224)	3,242	0	(591)	0	0	19,002	237,360
FY Total	**222,305**	**68,537**	**42,507**	**85,451**	**(2,223)**	**45,327**	**0**	**(2,239)**		**0**	**237,360**	**237,360**

Project Impacts

Waterfall Chart



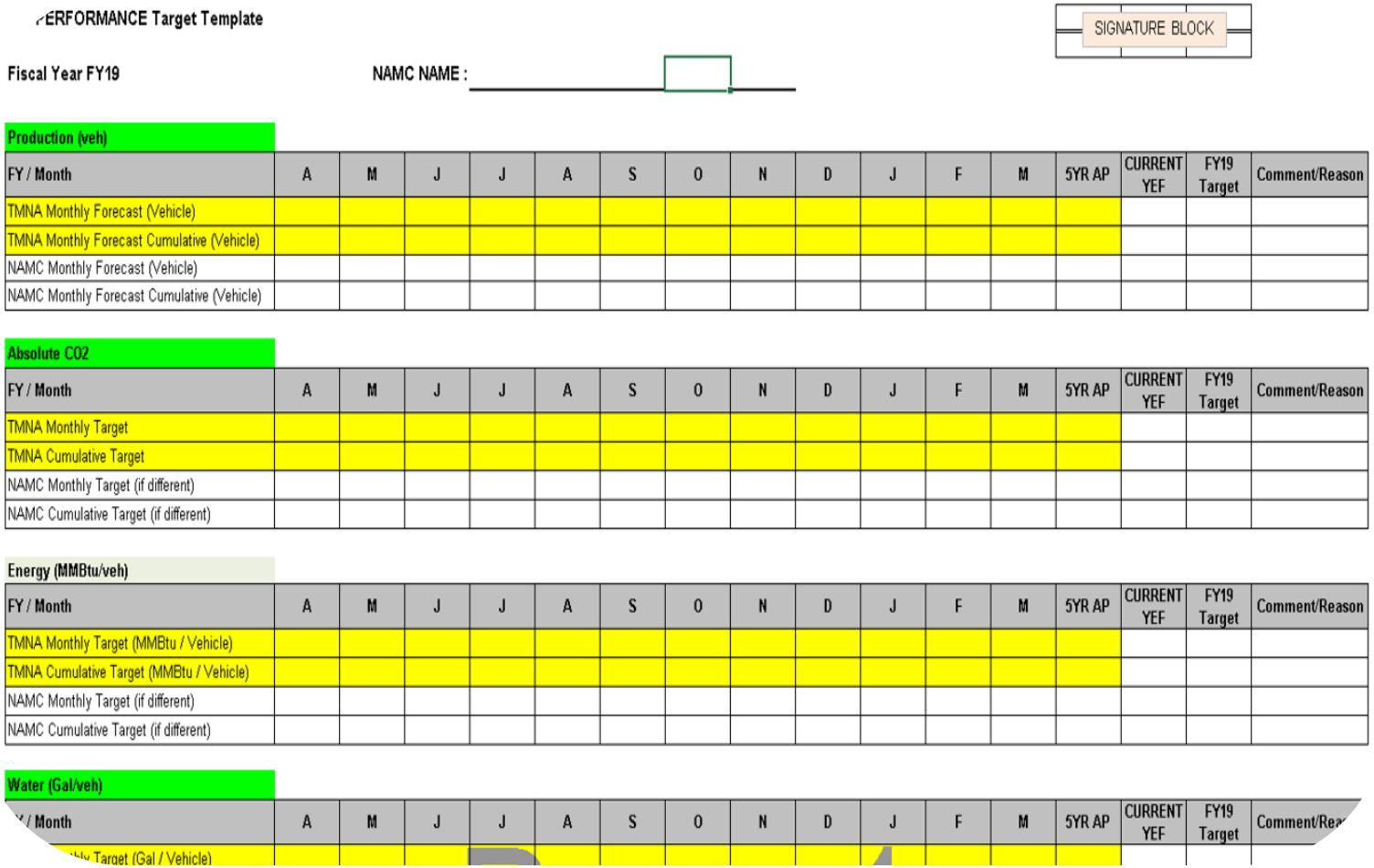
Target Templates

1 Prelim | 2 Data | 3 Analytics | 4 Impacts | 5 Templates

Target Setting

What do we propose?

- Review files
- One on one calls/meetings
- Sent out templates



ERFORMANCE Target Template

SIGNATURE BLOCK

Fiscal Year FY19 NAMC NAME :

Production (veh)

FY / Month	A	M	J	J	A	S	O	N	D	J	F	M	5YR AP	CURRENT YEF	FY19 Target	Comment/Reason
TMNA Monthly Forecast (Vehicle)																
TMNA Monthly Forecast Cumulative (Vehicle)																
NAMC Monthly Forecast (Vehicle)																
NAMC Monthly Forecast Cumulative (Vehicle)																

Absolute CO2

FY / Month	A	M	J	J	A	S	O	N	D	J	F	M	5YR AP	CURRENT YEF	FY19 Target	Comment/Reason
TMNA Monthly Target																
TMNA Cumulative Target																
NAMC Monthly Target (if different)																
NAMC Cumulative Target (if different)																

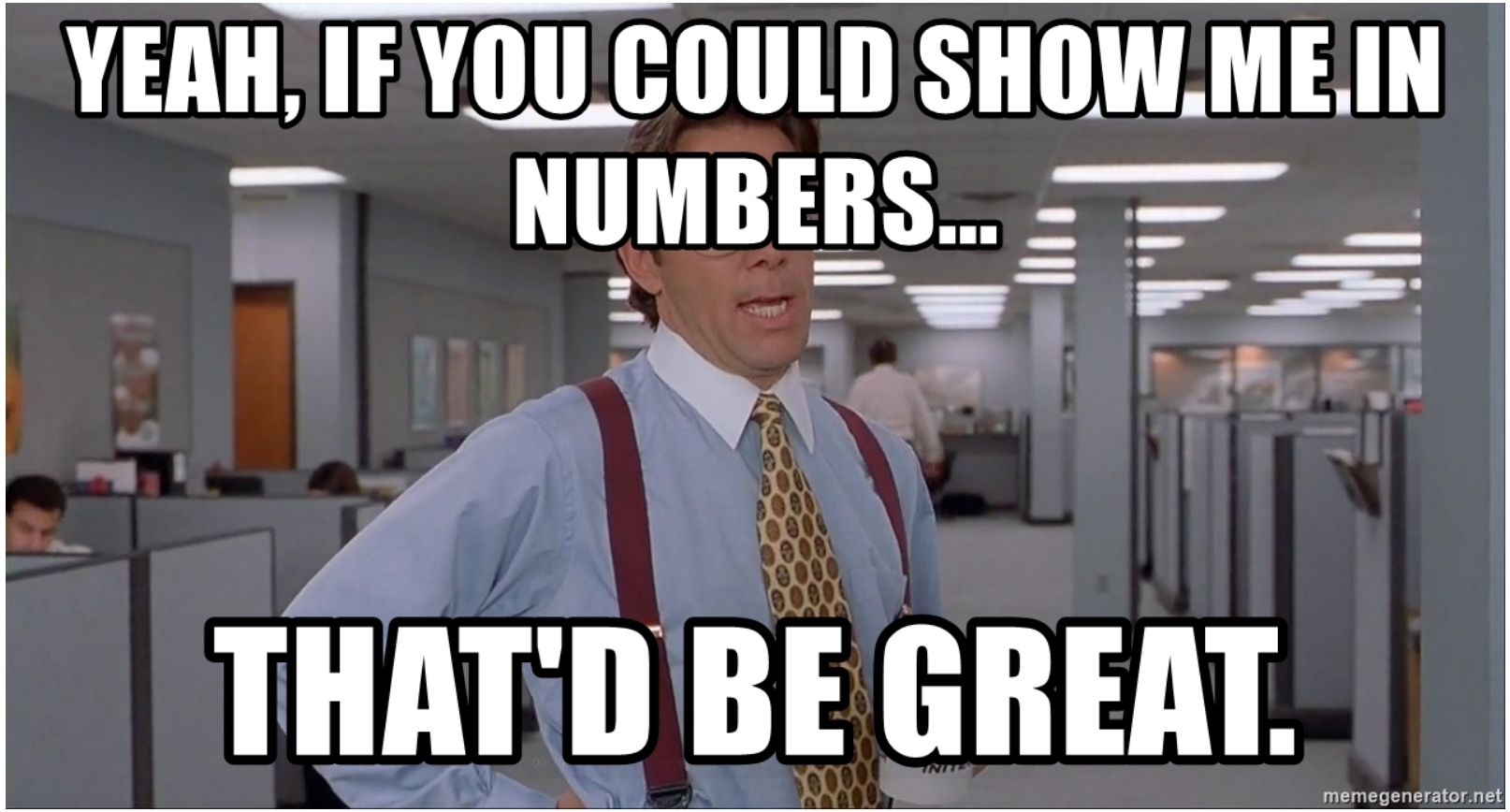
Energy (MMBtu/veh)

FY / Month	A	M	J	J	A	S	O	N	D	J	F	M	5YR AP	CURRENT YEF	FY19 Target	Comment/Reason
TMNA Monthly Target (MMBtu / Vehicle)																
TMNA Cumulative Target (MMBtu / Vehicle)																
NAMC Monthly Target (if different)																
NAMC Cumulative Target (if different)																

Water (Gal/veh)

/ Month	A	M	J	J	A	S	O	N	D	J	F	M	5YR AP	CURRENT YEF	FY19 Target	Comment/Rea
Target (Gal / Vehicle)																

Negotiation & Consensus



Let's Talk

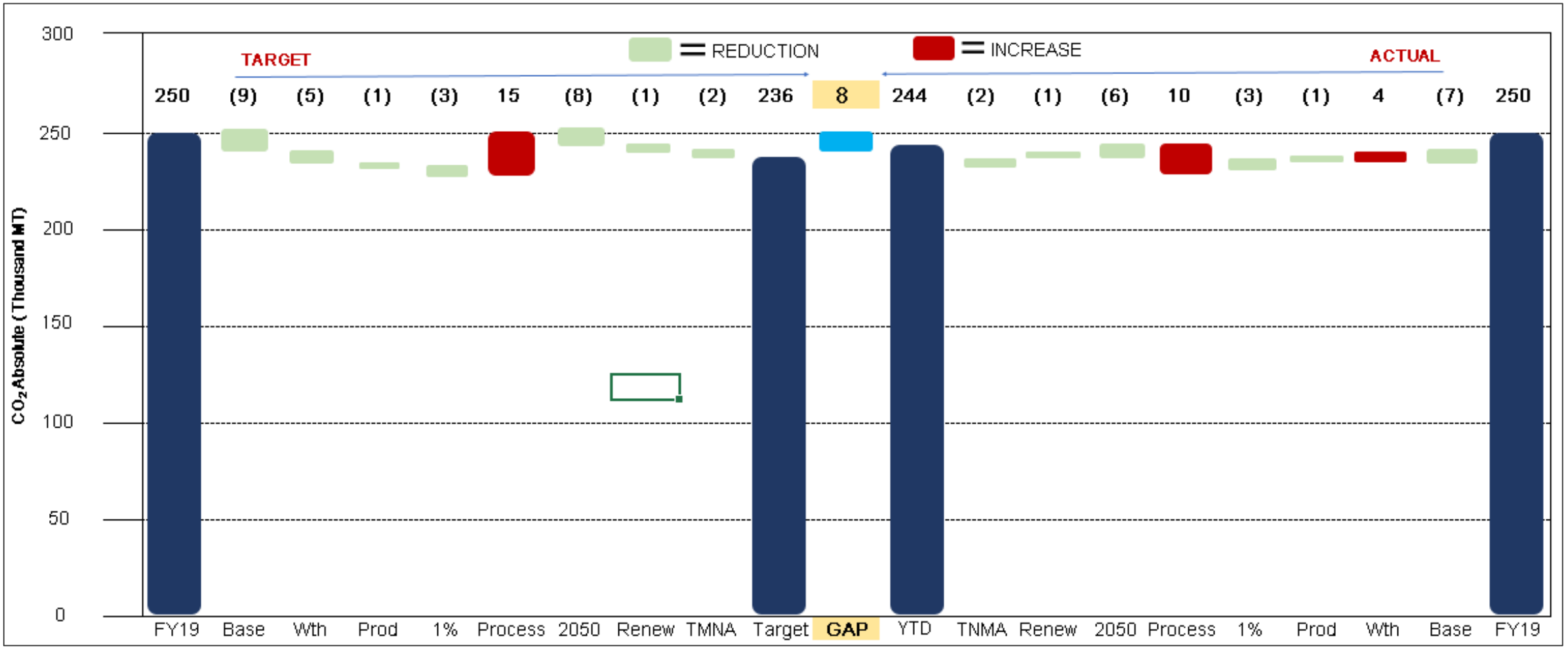
- Method used?
- What is included?
- Align with 5 Year Plan?
- Unplanned conditions?

Tracking Progress

Action

Tracking Targets

How are we doing?



or condition

If target setting is productive…

"May the metrics be forever in your favor"

Best Practices…

- Ideal Metrics
- Have a Plan
- Have Consensus
- Track Progress

THANK YOU

Energy & Water Analytics at P&G

August 2018

Journey

- Big Data & Analytics
- What we learned
- Recommendations

P&G AT A GLANCE

Countries of Operations: **~70**

Countries Where Our Brands Are Sold: **180+**

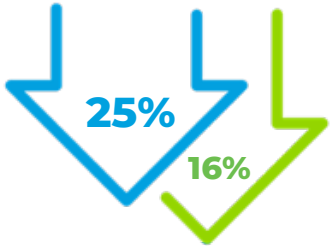
Consumers Served by Our Brands:
Nearly **5 Billion**

SOME OF THE WORLD'S MOST TRUSTED BRANDS

2020 GOAL PROGRESS

Within our operations we strive to grow responsibly, constantly improving our efficiency while reducing our footprint. Production has increased since 2010; however, we have successfully decoupled that growth from our environmental footprint.

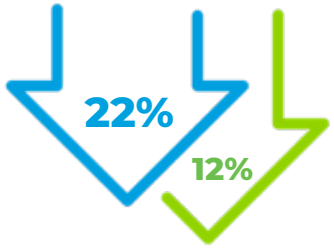
GHG



25% reduction per unit of production

16% absolute reduction

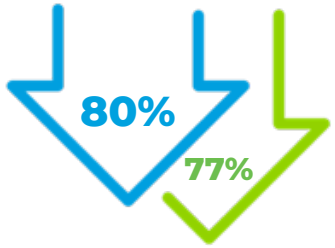
ENERGY



22% reduction per unit of production (exceeding goal early)

12% absolute reduction

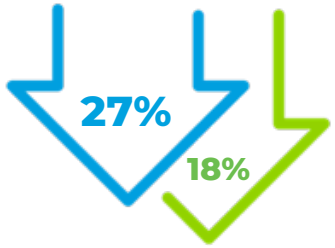
WASTE



80% reduction in solid waste with 72% of our sites achieving zero manufacturing waste to landfill

77% absolute reduction

WATER



27% reduction per unit of production (exceeding goal early)

18% absolute reduction

RENEWABLE ENERGY

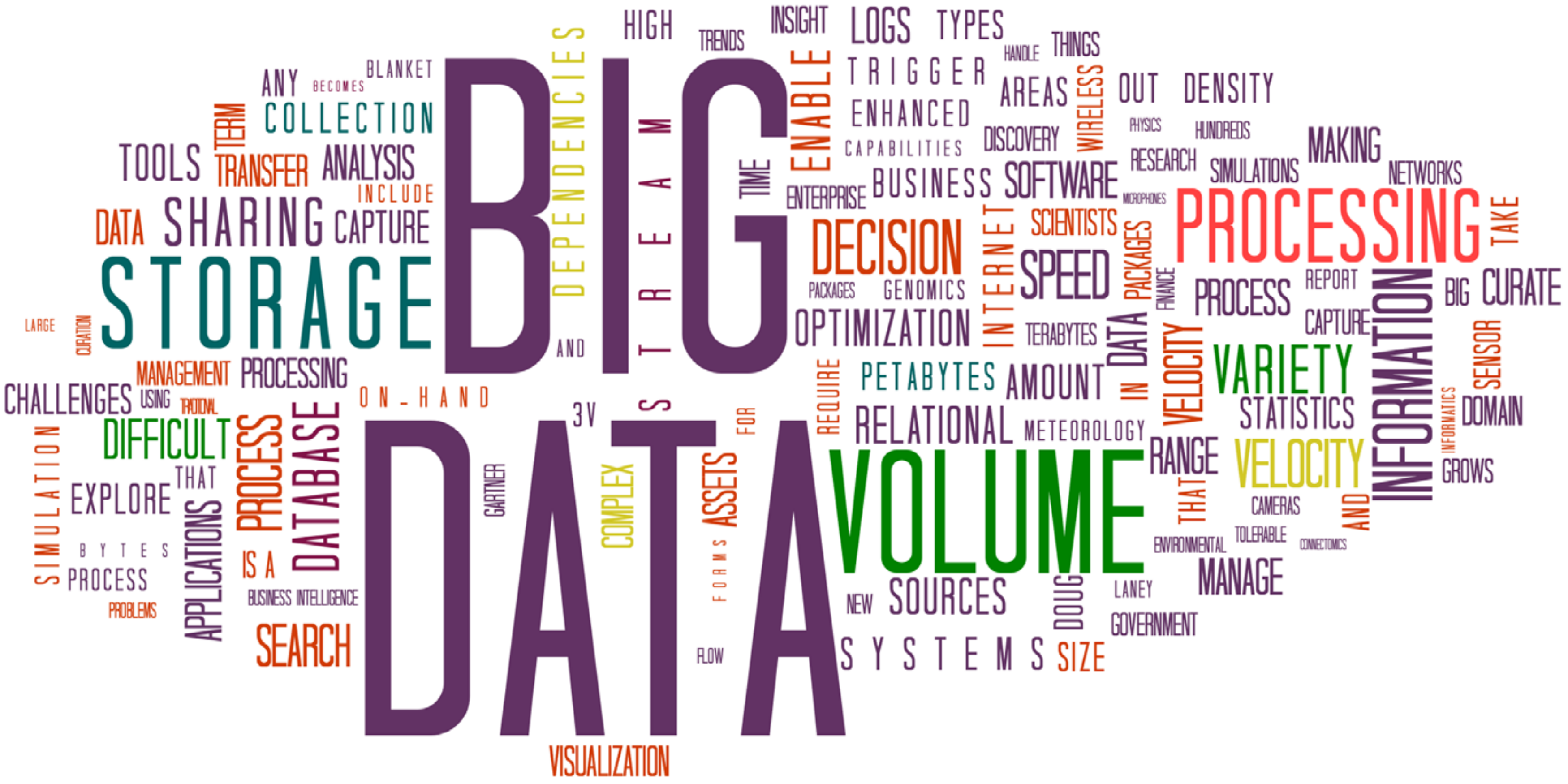
Currently **10%** with large scale wind farm and biomass projects coming online in the back half of the fiscal year that will double our usage to ~20%

Data

“From the dawn of civilization until 2003, humankind generated five exabytes of data. Now we produce five exabytes every two days…and the pace is accelerating.”

Eric Schmidt, Executive Chairman, Google

Is this new?

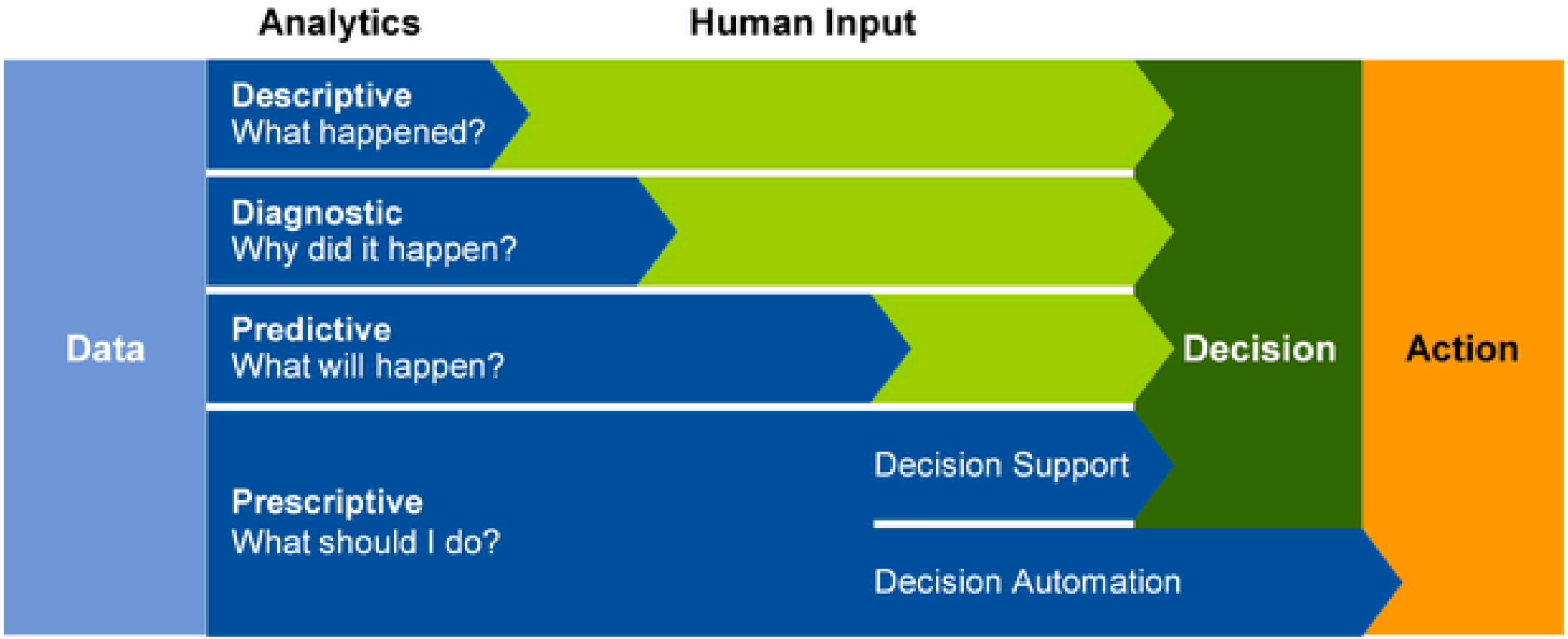


BIG
DATA
STORAGE
VOLUME
PROCESSING
VARIETY
VELOCITY
INFORMATION
DECISION
OPTIMIZATION
SHARING
COLLECTION
ANALYSIS
CAPTURE
TOOLS
TRANSFER
TERM
INCLUDE
ANY
BECOMES
BLANKET
DEPENDENCIES
STREAM
HIGH
TRENDS
INSIGHT
LOGS
TYPES
TRIGGER
ENHANCED
CAPABILITIES
ENABLE
TIME
ENTERPRISE
BUSINESS
SOFTWARE
DISCOVERY
AREAS
WIRELESS
THINGS
HANDLE
OUT
DENSITY
PHYSICS
HUNDREDS
RESEARCH
SIMULATIONS
MAKING
NETWORKS
SCIENTISTS
SPEED
INTERNET
PACKAGES
GENOMICS
TERABYTES
PROCESS
REPORT
CAPTURE
BIG
CURATE
TAKE
PETABYTES
AMOUNT
RELATIONAL
METEOROLOGY
STATISTICS
RANGE
DOMAIN
SENSOR
GROWS
CAMERAS
TOLERABLE
ENVIRONMENTAL
MANAGE
LANEY
GOVERNMENT
DOUG
SOURCES
NEW
SYSTEMS
SIZE
REQUIRE
FOR
ASSETS
FORMS
FLOW
COMPLEX
GARTNER
3V
ON-HAND
AND
VISUALIZATION
SEARCH
BUSINESS INTELLIGENCE
DATABASE
PROCESS
IS A
APPLICATIONS
THAT
DIFFICULT
EXPLORE
BYTES
PROCESS
PROBLEMS
SIMULATION
CHALLENGES
USING
TRADITIONAL
MANAGEMENT
PROCESSING
LARGE
CURATION
DATA

Value of data

Ability to hear the signal from the noise is crucial…

It is all about ACTIONABLE INSIGHTS



Source: Gartner (October 2014)

THE CHALLENGES

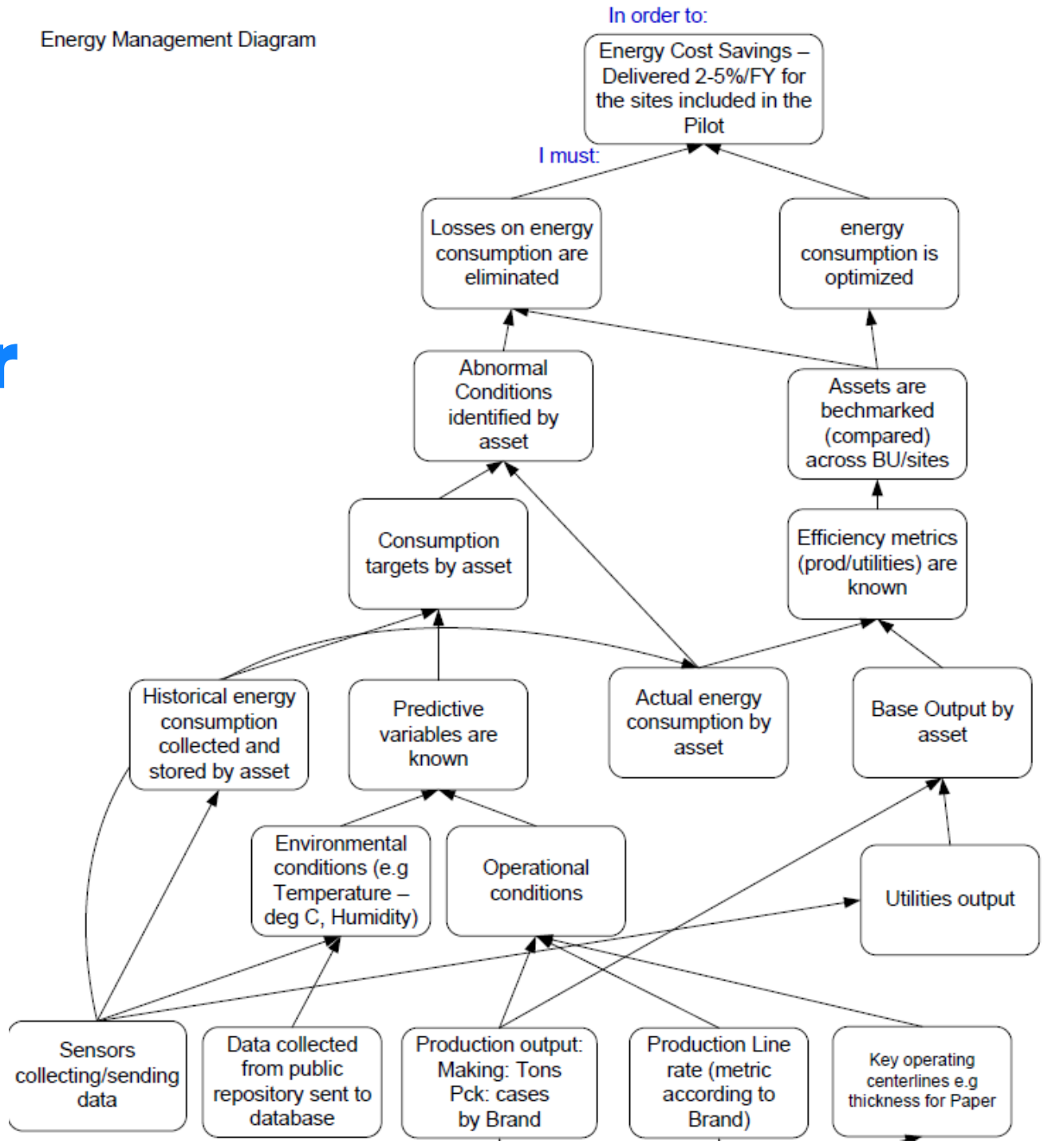
ARCHITECTURE: Centralizing data requires a clear flow of data from operating floor.

STORAGE INFRASTRUCTURE: Enterprise infrastructure is evolving rapidly

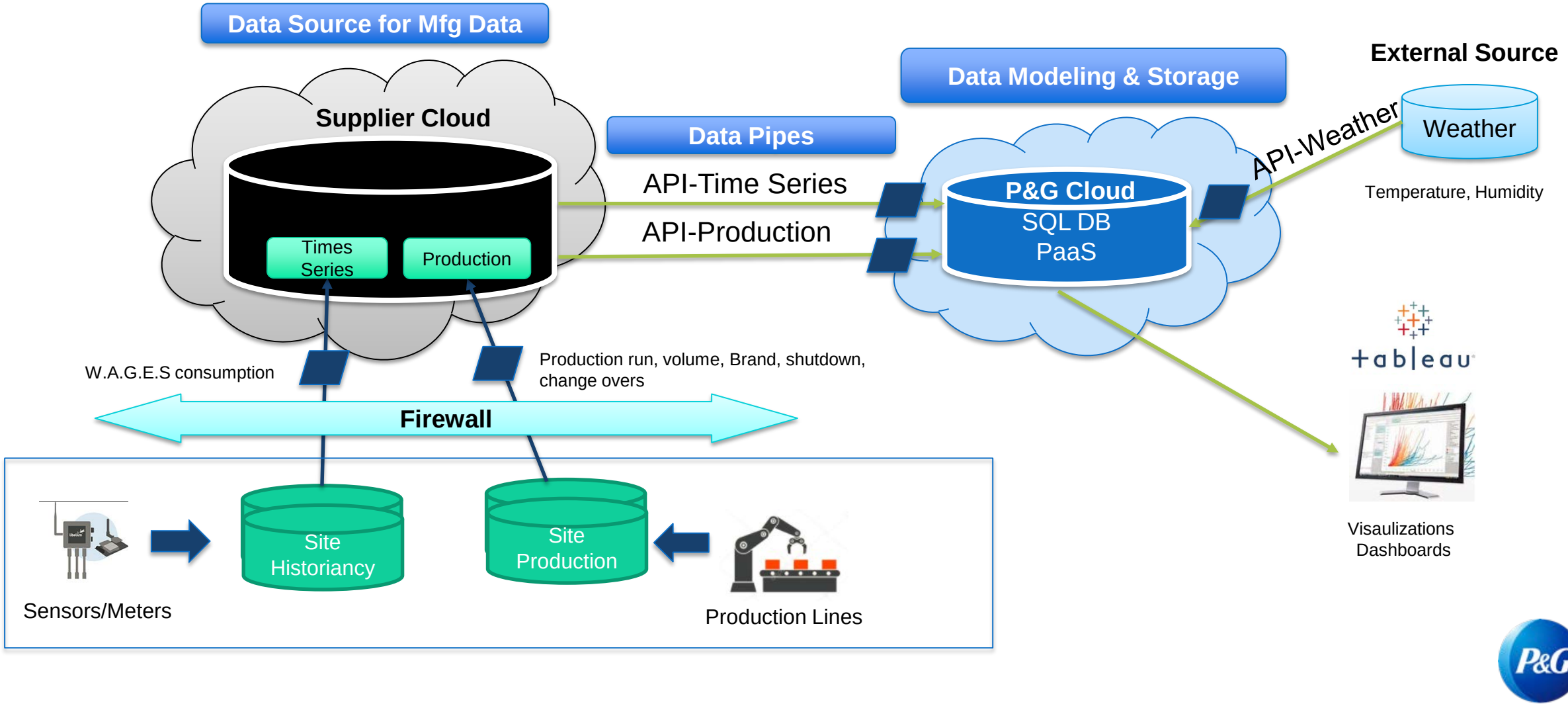
DATA HARMONZIATION: Data was there for 20-30 years. First time pulling it all together.

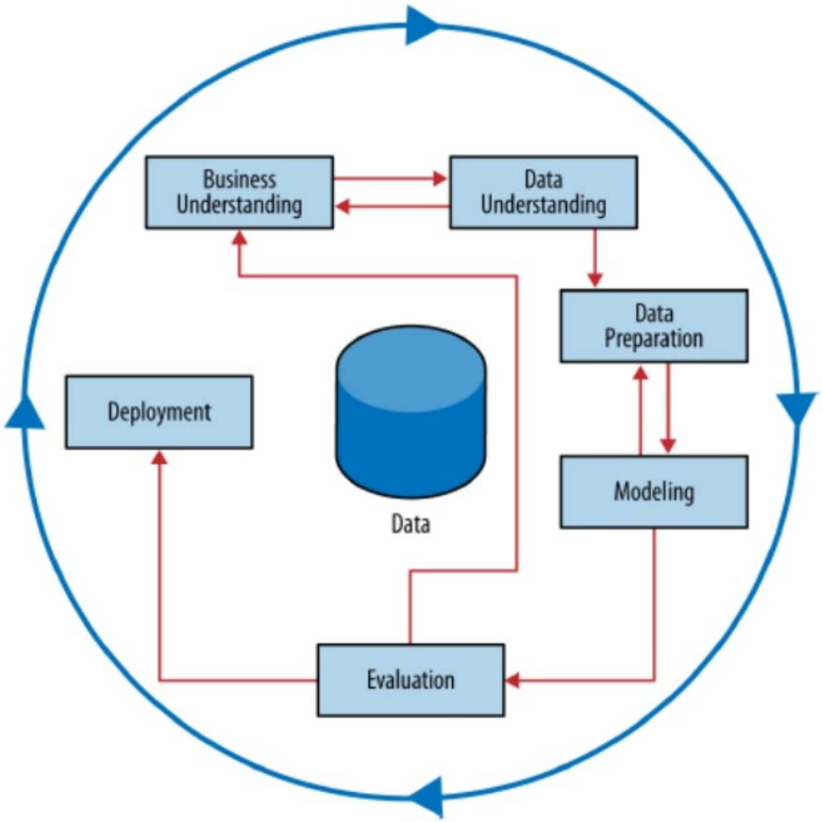
SUPPLIERS: There is big money in energy data. Everyone is knocking on our door.

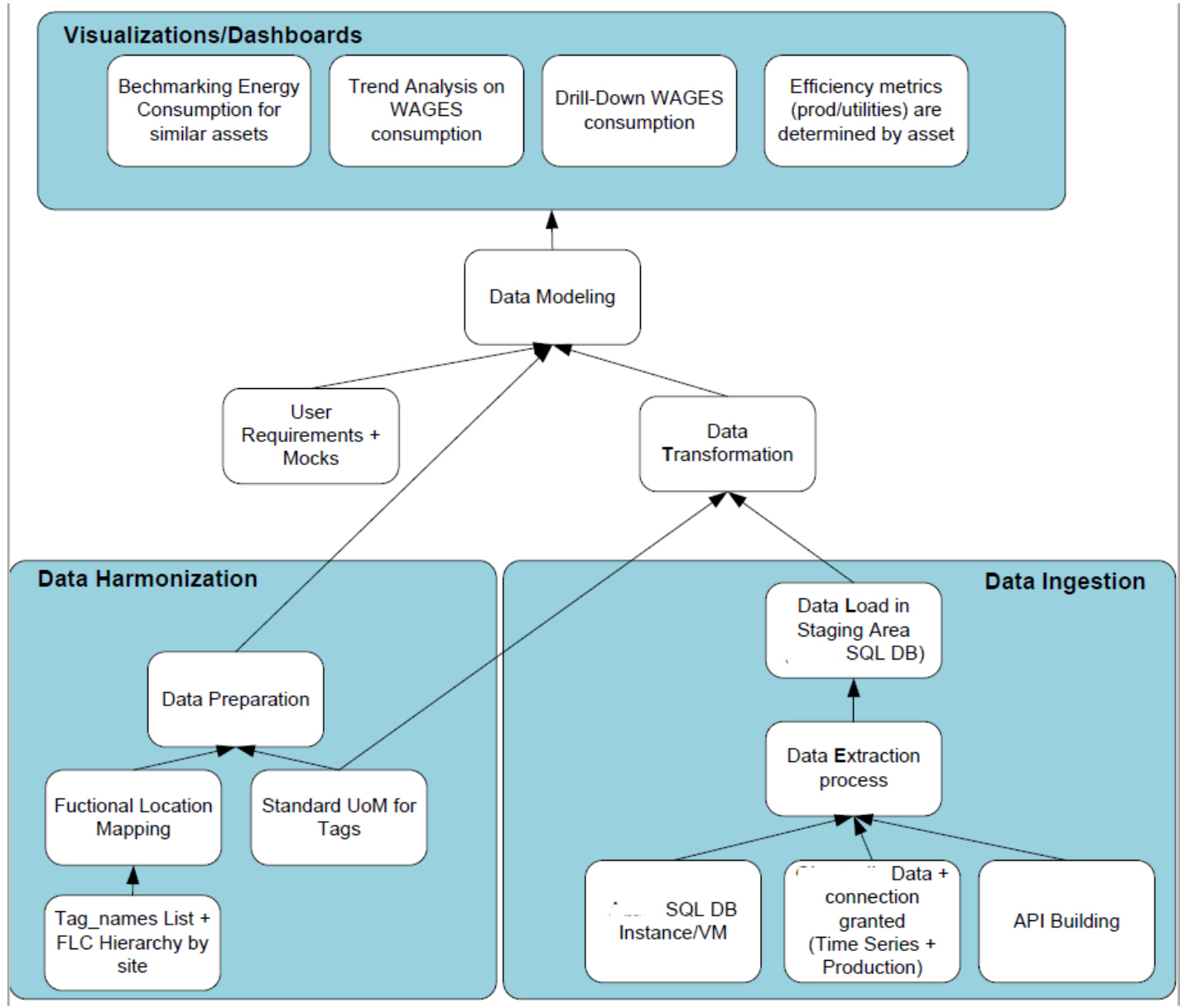
Energy & Water Analytics Proof of Concept



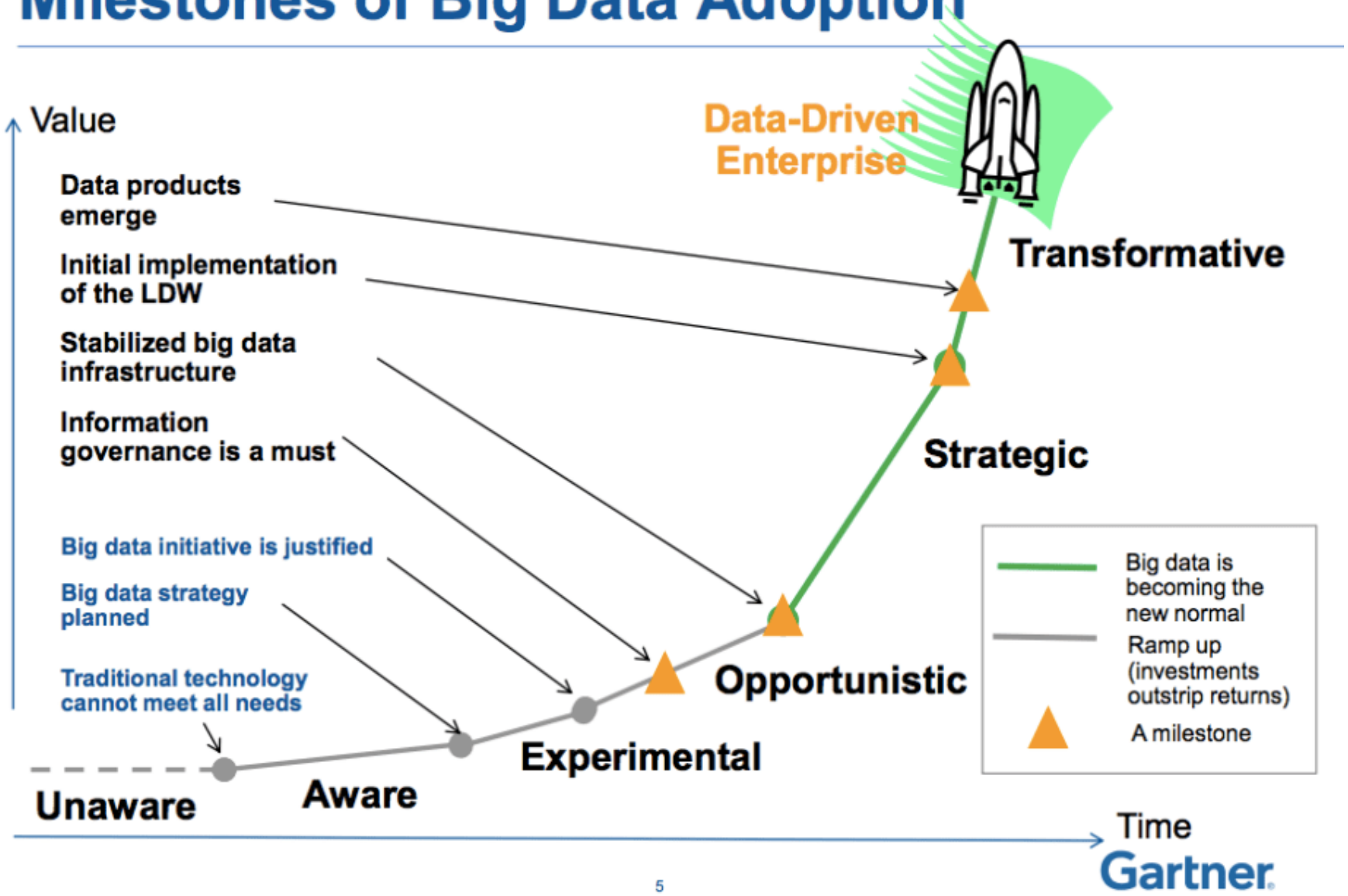
Energy & Water Analytics Proof of Concept




Business Understanding
Data Understanding
Data Preparation
Modeling
Evaluation
Deployment
Data


Visualizations/Dashboards
Bechmarking Energy Consumption for similar assets
Trend Analysis on WAGES consumption
Drill-Down WAGES consumption
Efficiency metrics (prod/utilities) are determined by asset
Data Modeling
User Requirements + Mocks
Data Transformation
Data Harmonization
Data Preparation
Fuctional Location Mapping
Standard UoM for Tags
Tag_names List + FLC Hierarchy by site
Data Ingestion
Data Load in Staging Area SQL DB)
Data Extraction process
SQL DB Instance/VM
Data + connection granted (Time Series + Production)
API Building

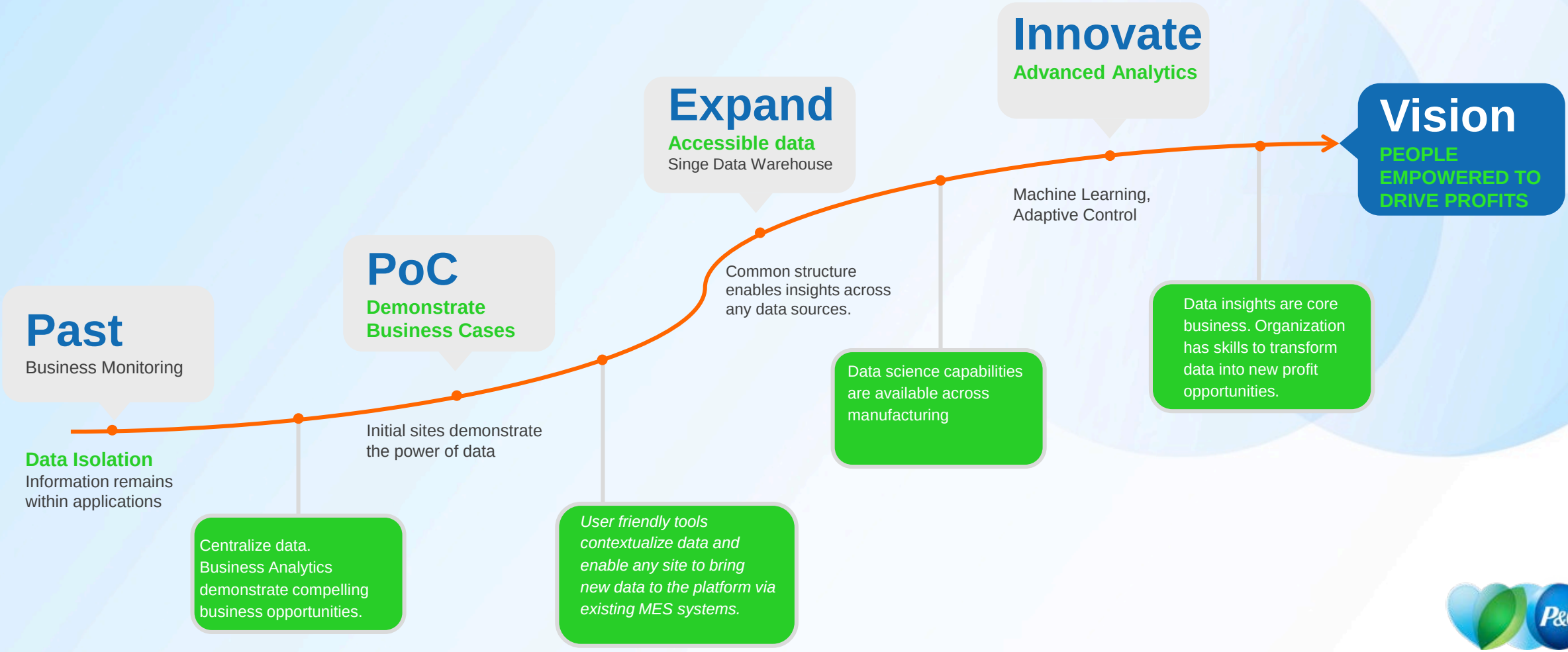
The Road Map: Typical Stages and Milestones of Big Data Adoption



Roadmap

LEADING THE TRANSFORMATION OF DATA INTO PROFITS

DATA IS ACCESSIBLE | COMMON STRUCTURE | UNLEASH ORGANIZATION TO CREATE INSIGHTS



Recommendations

- Engage and Staff IT Leadership on project
- Start with clear user & business requirements
- Seek help from experts in Data Science and Infrastructure


P&G
THANK YOU

Metrics and Big Data

Large Facility Energy Analysis

Presented by: Anand Varahala

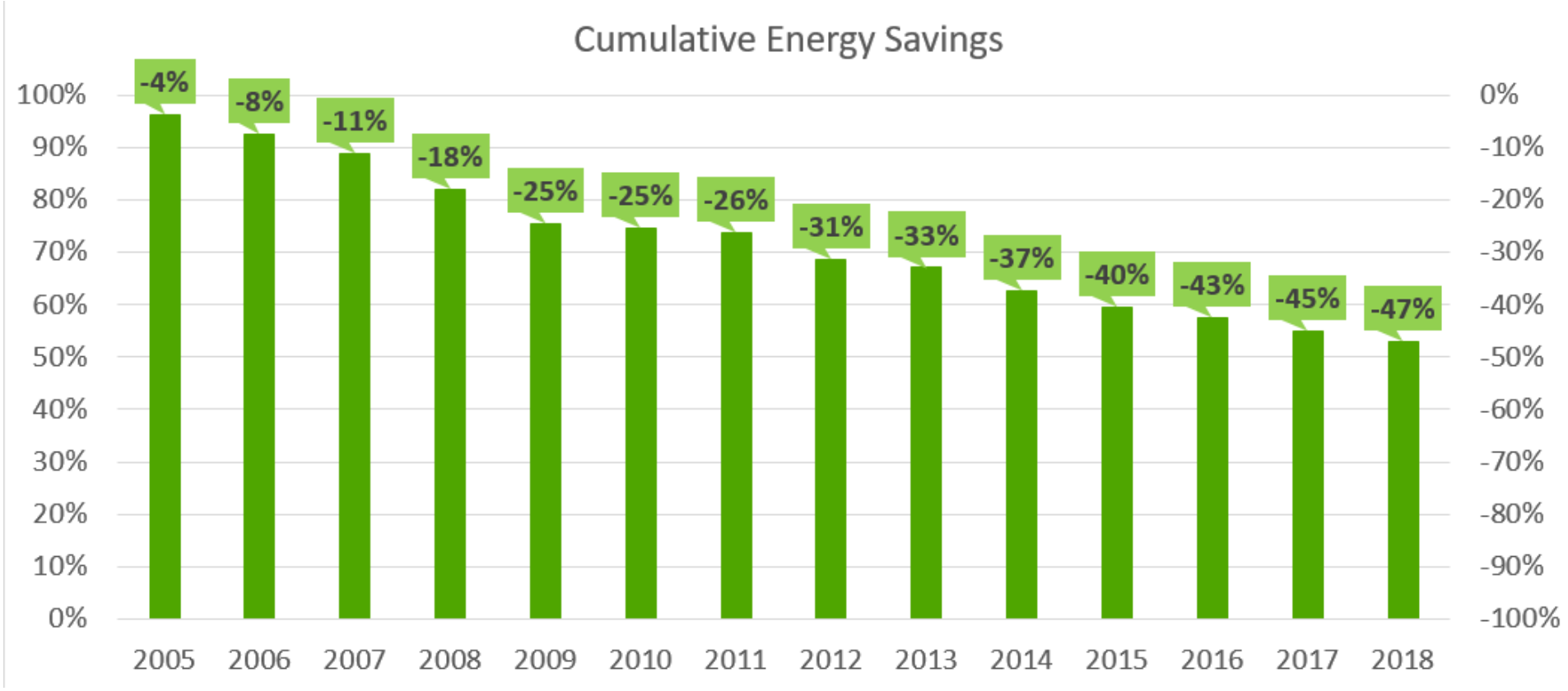
Schneider Energy Action – North America

A little history…

- Inception in 2005 with 26 facilities
- Strategic partnership between Global Supply Chain and Energy & Sustainability Services
- 65 managed facilities across Canada, Mexico, and USA
- 5 GSC Clusters, 4 Business Operations represented

Program Performance

Cumulative energy savings (electricity & natural gas) normalized for weather and production



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How do we measure performance?

KPI – Energy Model

BU / Cluster	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	'18 vs '17 Baseline		Elec	Gas
GSC NA - CTO/ETO Total	-3%	-4%	-2%	-2%	-4%	-15%	-5%		-8%	-2%
GSC NA - Electronics Total	-11%	-19%	-13%	-16%	-20%	-22%	-17%		-15%	-27%
GSC NA - ETO/CTO Total	-14%	-1%	-2%	-4%	-7%	-6%	-6%		0%	-10%
GSC NA - Logistics Total	6%	17%	13%	6%	-5%	0%	7%		-4%	24%
GSC NA - MTS/MTO Total	1%	-1%	6%	4%	3%	0%	2%		0%	6%
Industry Total	0%	-15%	-3%	-9%	-6%	-5%	-6%		-3%	-18%
Buildings & IT Total	11%	9%	6%	-5%	-6%	-14%	1%		-6%	16%
Operations NA Total	-16%	-5%	-5%	-9%	-7%	-4%	-8%		-6%	-15%
Grand Total	-5%	-2%	0%	-2%	-4%	-7%	-3%		-4%	-3%

Benefits

- Linear regression analysis
- Unique model for each site
- Utility invoice data (> 200 invoices per month)
- Weather data (cooling and heating degree days)
- Production and activity data
- Whole facility energy performance

Challenges

- Calendarization
- Time intensive invoice data processing
- Delay in reporting (What happened 6 weeks ago?)
- Timely identification of issues

The Incident, the Problem, and the Opportunity

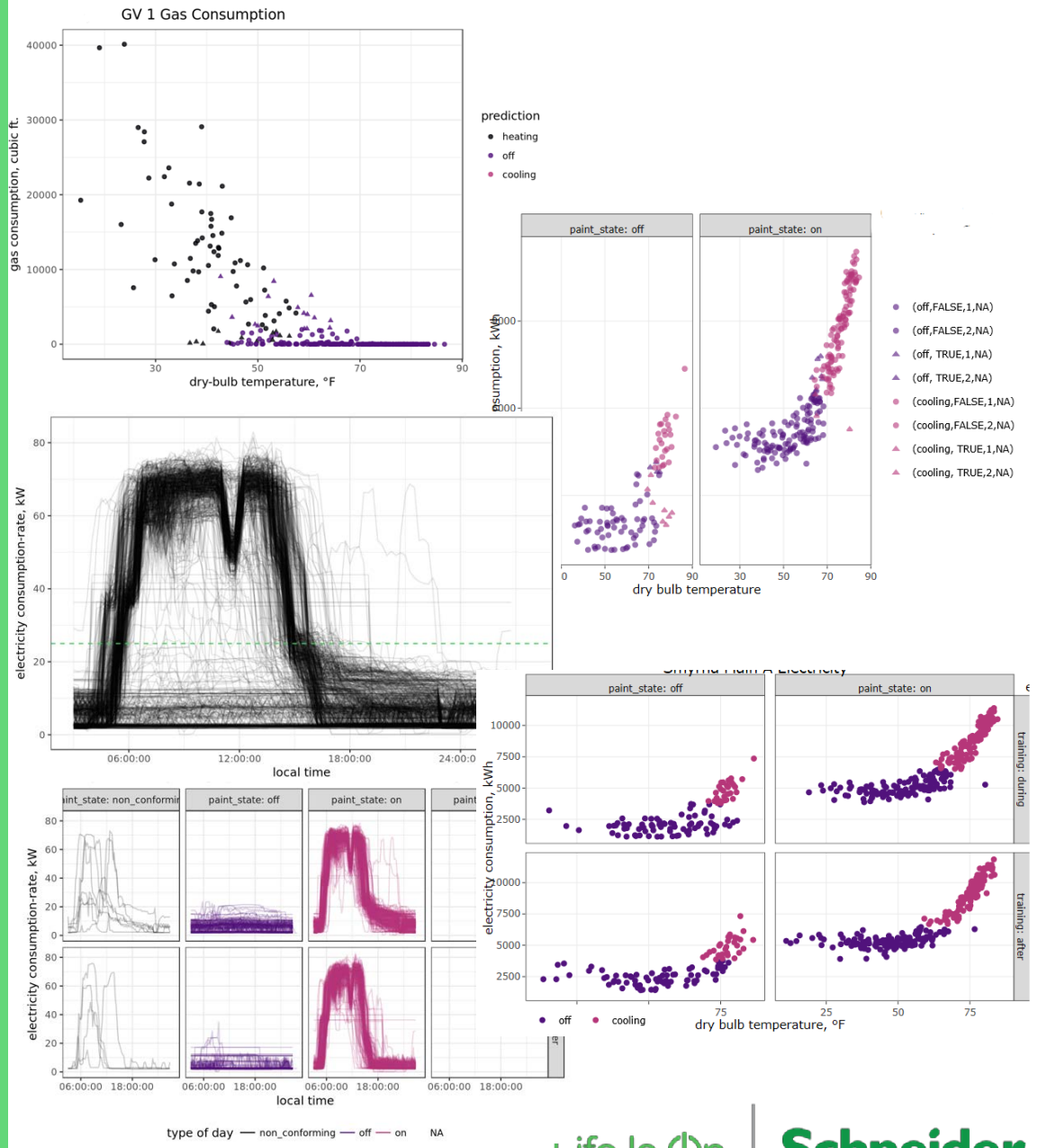
- Q1 2016
- Significant increase in gas consumption
- > 55k USD impact
- 2 months to identify deviation
- 3 months to confirm trend
- Reactive response

- Monthly frequency of the Energy Model reports
- Dependence on utility invoices
- Time/labor intensive process
- 4 to 6 week delay in determining deviations

- Existing network of sub-meters
- Central monitoring software
- Access to weather data through web-services (API)
- In-house expertise
- Strong collaboration with Analytics and Artificial Intelligence team

The Concept

- A daily ‘energy model’
- Take advantage of interval data from existing meters
- Develop production/activity related ‘features’ by analyzing the 15-minute interval electricity and gas consumption data
- Create visualization that is easy to read, interpret, and, understand



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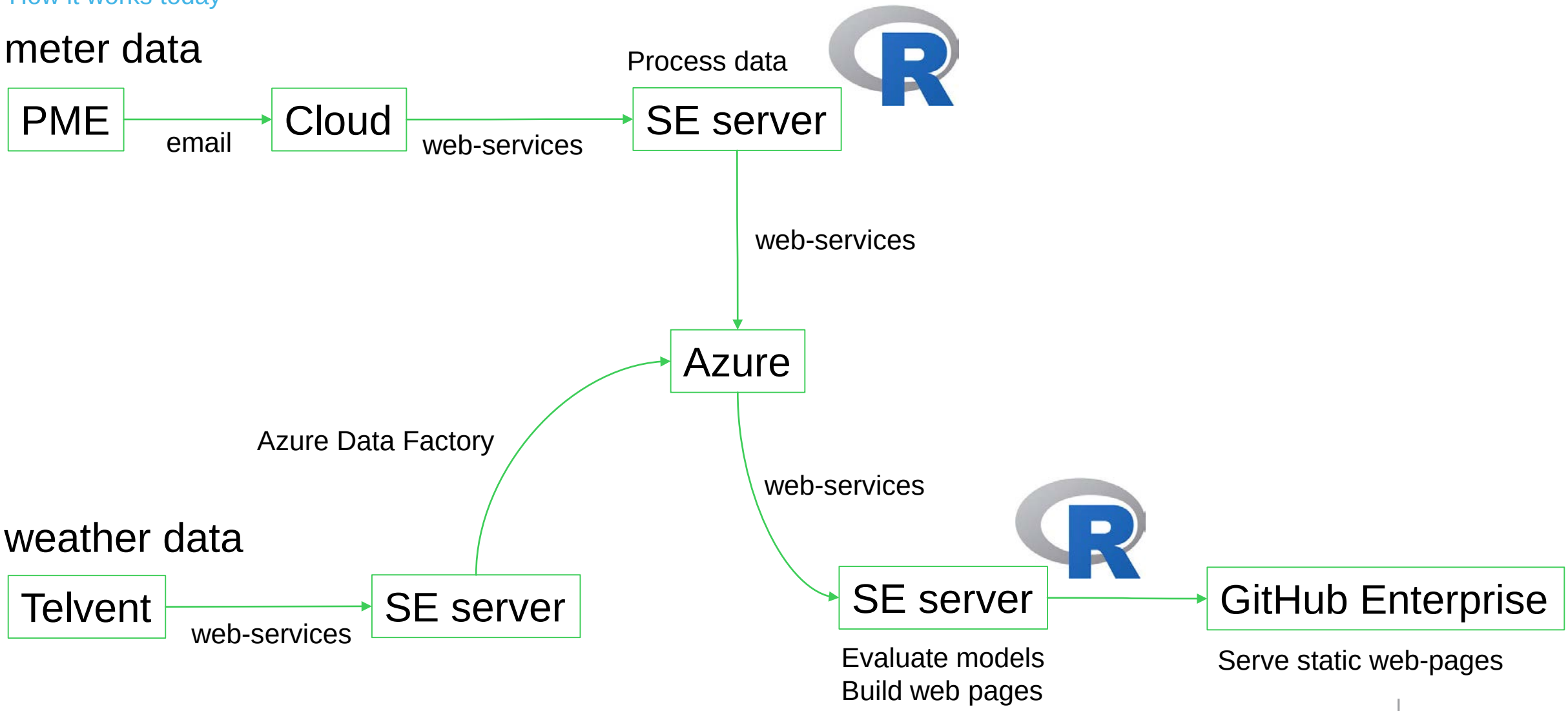
Architecture

How it works today



Daily Energy Model

Data Acquisition

+

Analytics

+

Visualization

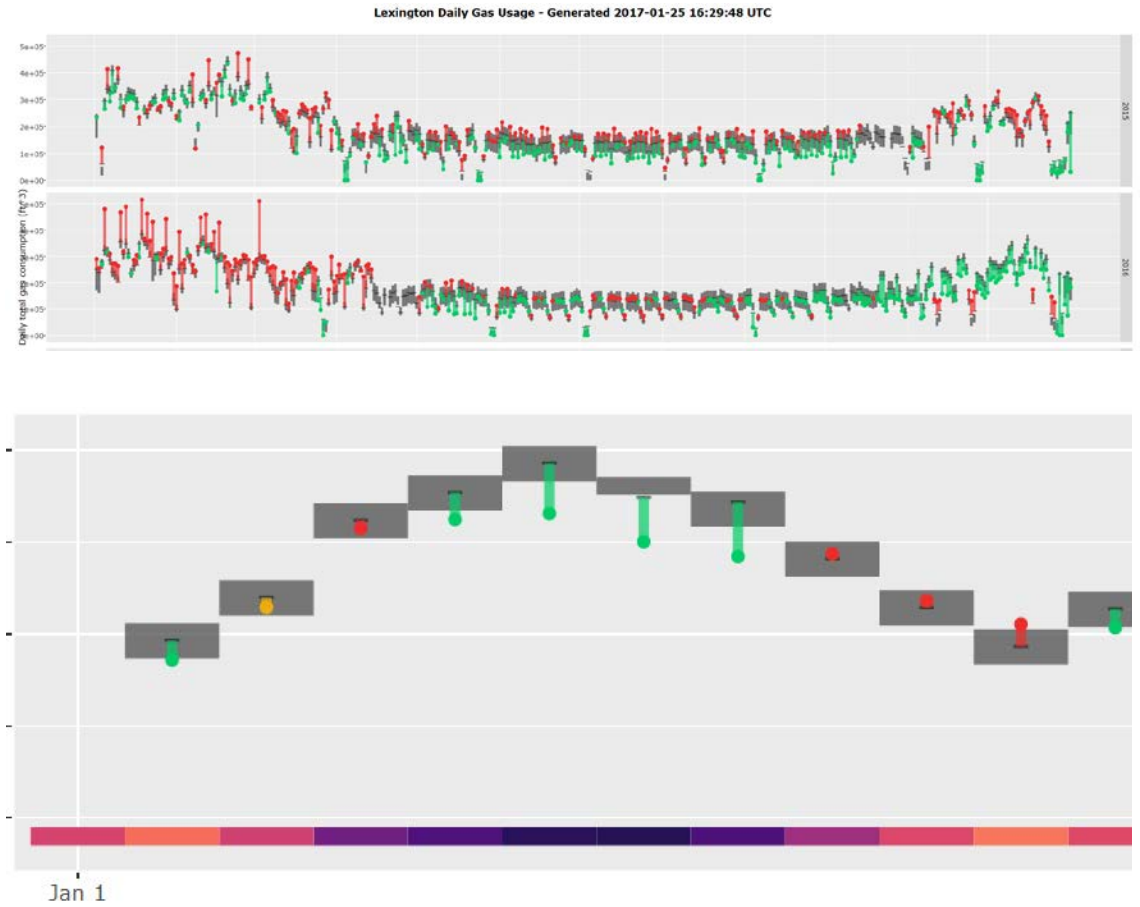
=

Detect and correct problems before they become expensive:

- In Q1 of 2016, spent 55 kUSD more than expected on gas, but did not know for over two months
- We developed a daily, normalized energy-usage model and visualization of the facility's energy performance.
- The facilities management team uses this tool daily to assess performance and to avoid subsequent problems.
- Allows on-site operators and SE facilities management to detect and correct problems before they go out of control

Daily Energy Model

- Shows performance on a daily basis so actions can be taken more quickly
- One model for gas and one model for electricity
- Predicted daily range in gray, with color-coded performance (details by hovering) to align with goals
- Outside temperature scale color-coded along bottom (details by hovering)



Future

- Robustness – streamlined
- Industrialization – mass producibility
- EcoStruxure architecture – near real time production data
- Full integration into existing software

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