

**TOYOTA MOTOR
MANUFACTURING,
KENTUCKY
LANDFILL GAS TO
ENERGY PROJECT**

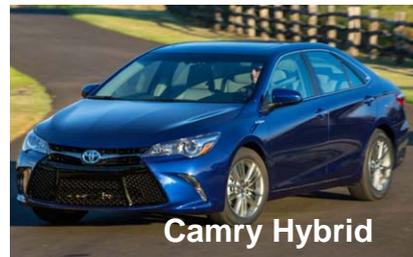
CHRIS ADKINS

TOYOTA



TOYOTA MOTOR MANUFACTURING KY

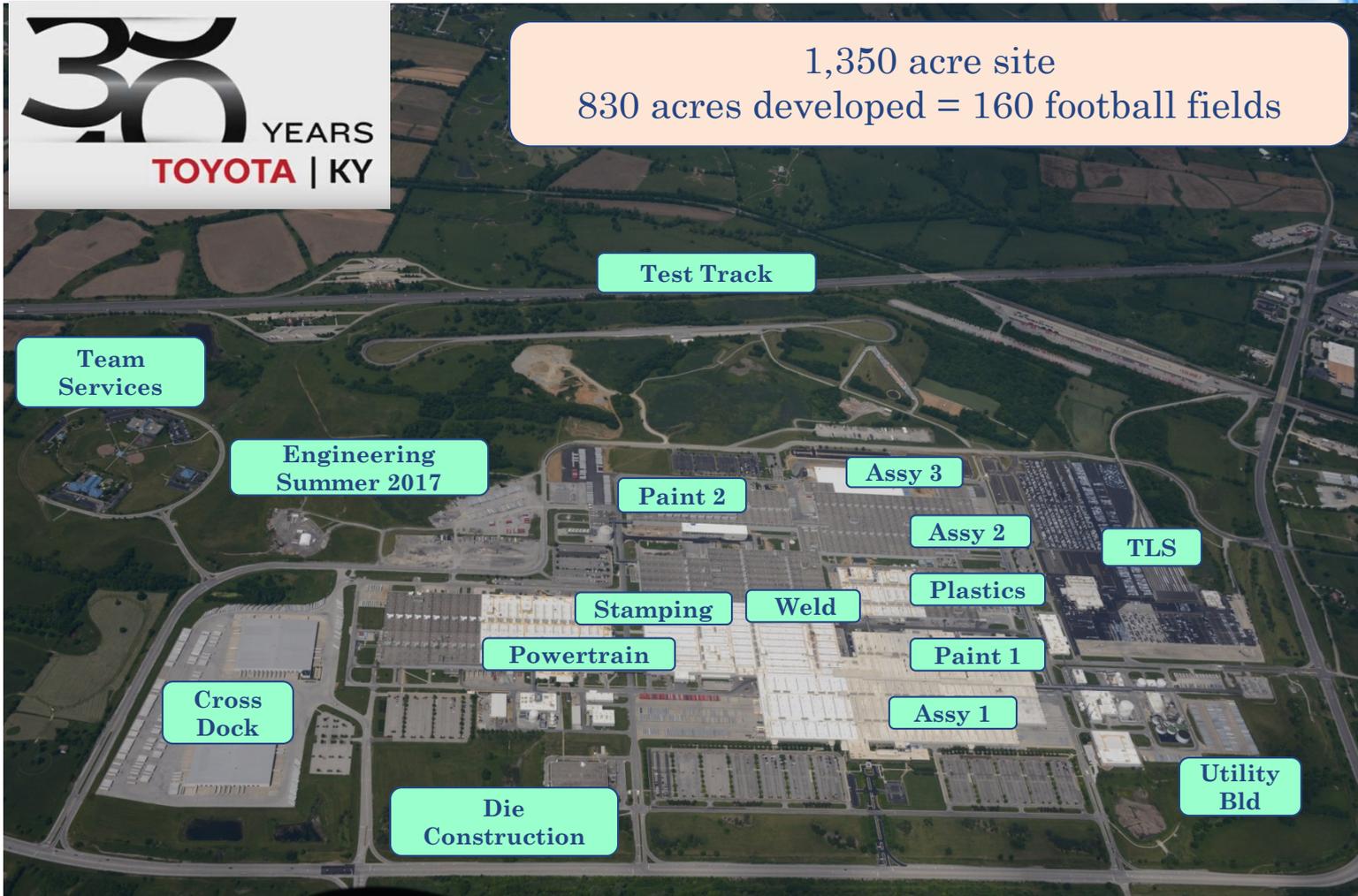
1. Camry & Camry Hybrid, Avalon & Avalon Hybrid, Venza, Lexus ES 350
2. Powertrain: 4 cylinder & V-6 engines
3. Annual production 500,000 vehicles & 600,000 engines
4. Employ 8000 team members, 2 production shifts & 4 maintenance shifts



TOYOTA MOTORS MANUFACTURING KY

30 YEARS
TOYOTA | KY

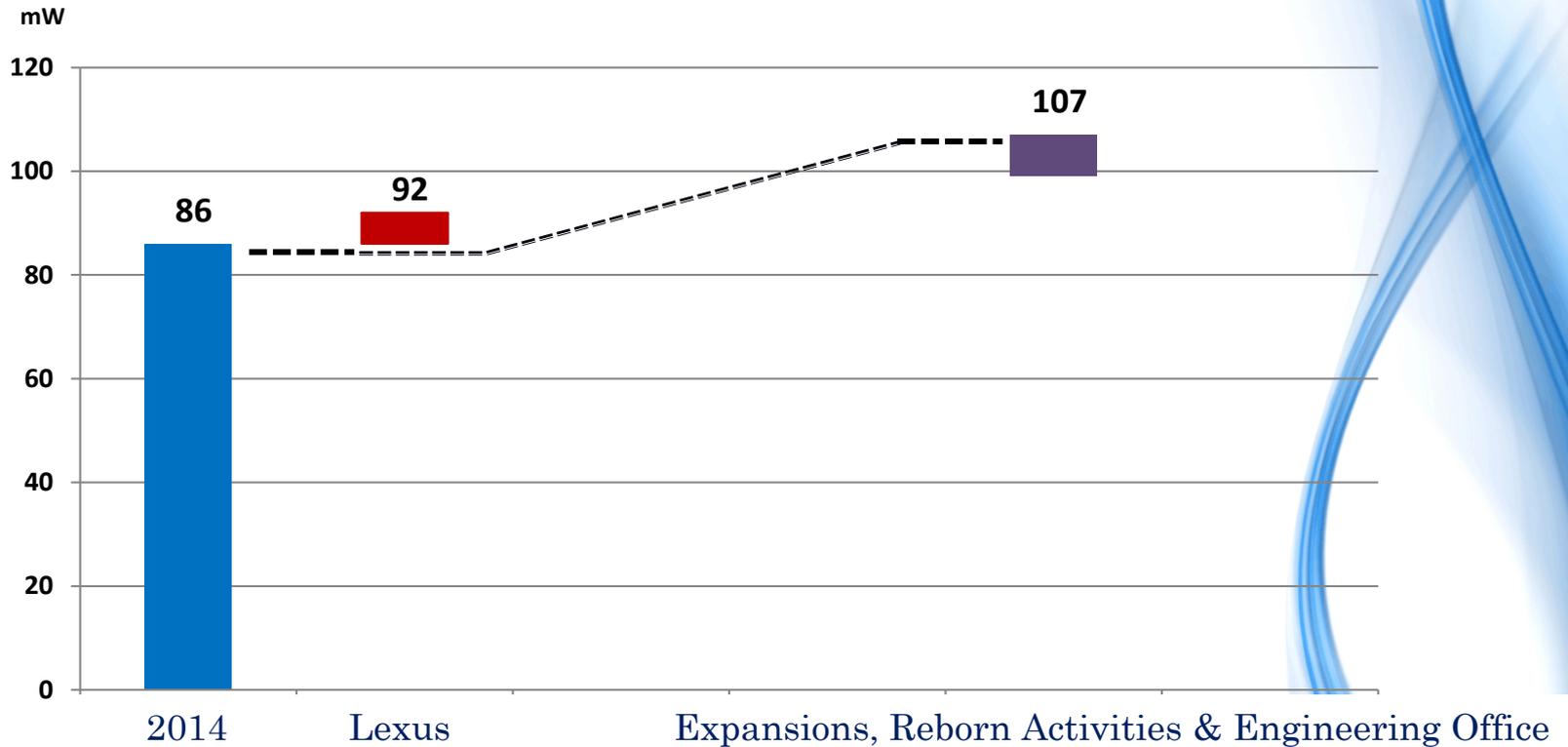
1,350 acre site
830 acres developed = 160 football fields



TOYOTA ENVIRONMENTAL CHALLENGE 2050



TMMK ENERGY LOAD GROWTH PLAN



Electricity usage will increase over 20%

IDEAS TO MINIMIZE CO2?

ITEM	CO2 GENERATION	COST	FEASIBILITY
Solar Array	Zero	Cost / KW high	Only 30% effective in KY
Wind Turbine	Zero	Cost / KW high	Only 35% effective in KY
Combined Heat Process	Low CO2	Higher energy usage to generate	Location remote from hot water process
Electricity from Landfill Gas	Low CO2 & reduces CO2 release from landfill	Fixed cost long term contract	Landfill has enough gas for 1MW of electricity generation that will grow over time

PROJECT SIGNIFICANCE

1. First non-utility business to business LFG project in Kentucky
2. First LFG to electricity project globally for Toyota

HOW DOES IT WORK?

1. Municipal Solid Waste breaks down naturally in landfills, creating landfill gas (50% methane)
2. A network of wells collects and prepares the landfill gas
3. Landfill gas is used to fuel generators, producing renewable electricity
4. Electricity is transmitted through underground lines to TMMK
5. Renewable electricity created from the landfill will be used to power the production of 10,000 vehicles per year



Landfill greenhouse gas emissions will be cut by an estimated 95 %, which adds up to better air quality for the local community

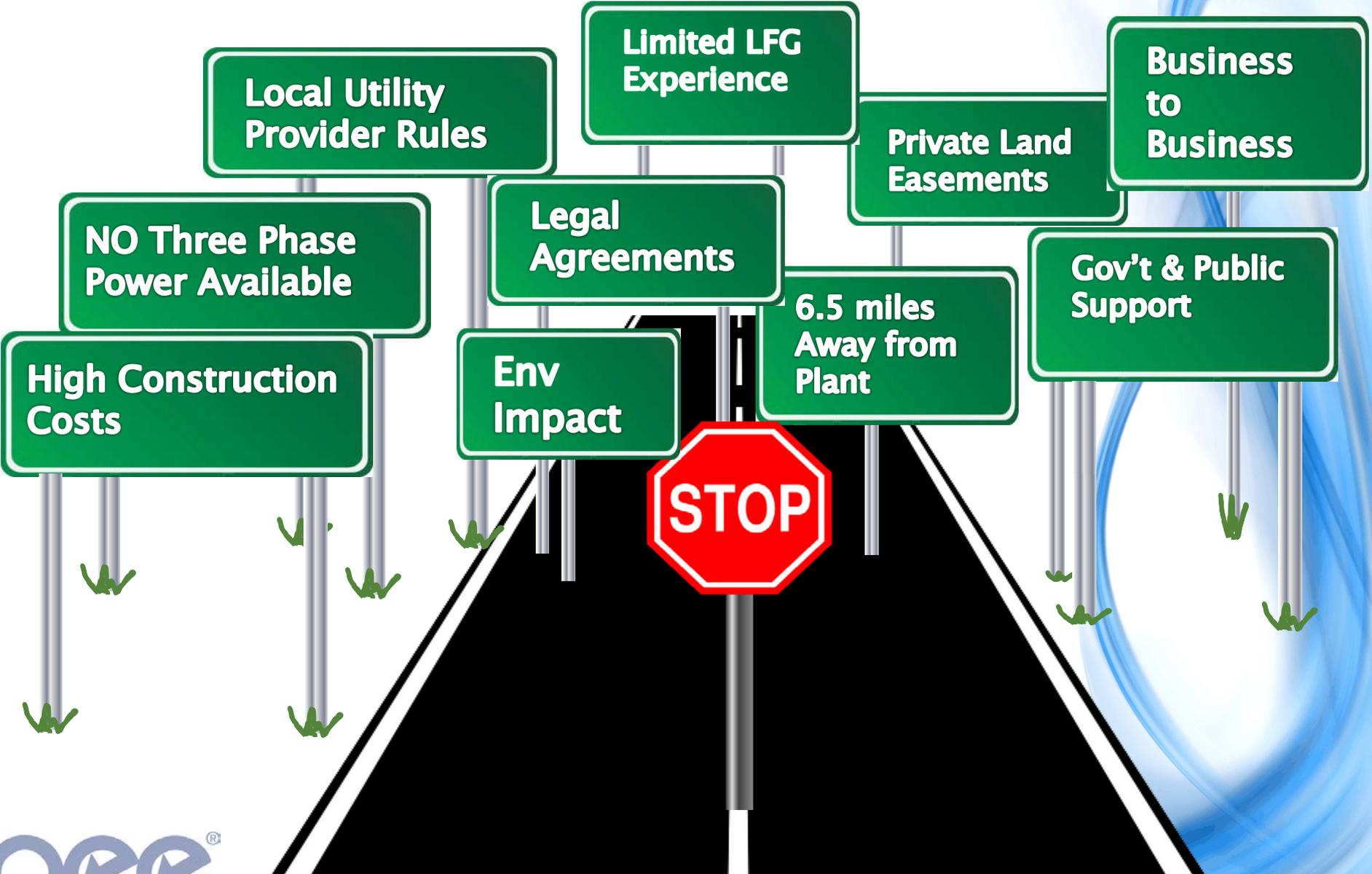
PARTNERING WITH THE LOCAL LANDFILL

1. Owner receptive to project.
2. Landfill had 1.2M tons of waste in place.
3. 400 tons per day of new waste inflow. Potential for that to increase.
4. Landfill Gas Emissions Model (Land-GEM) study revealed sufficient gas flow for 1Mw of electricity production.
5. Agreement for joint LFG venture.

ESTIMATED CO₂ REDUCTIONS

1. Grid electricity for KY averages 9,000 Tons of CO₂ per year per mW.
2. Methane equivalent escaping from landfill averages 42,000 Tons of CO₂ per year per mW.
3. Combustion of the landfill methane creates an average of 5,000 tons of CO₂ per year per mW.
4. Net reduction of 46,000 Tons of CO₂ per year per mW.
 - a. $(9,000 + 42,000) - 5,000 = \text{Net reduction of } 46,000 \text{ T}$

INITIAL CHALLENGES



Toyota had no experience with generating electricity from landfill gas

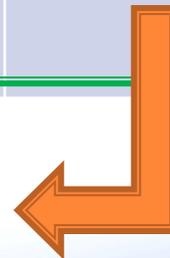


VISITS	SYSTEM	LEARNING
#1	Landfill gas is piped to the site – installed by NG gas co. Direct burn and generate electricity	1. Gas company owns/installed/maintains line, obtained easements. 2. Siloxanes issues - Installed gas conditioning system
#2	Electricity generation by power company and put on grid	1. Power company adjacent to landfill. 2. Siloxane issues - PM program set up.
#3	Electricity generation by third party operator and sold to power company	1. De-regulated state. 2. Siloxanes initially removed by gas conditioning system as preventive measure

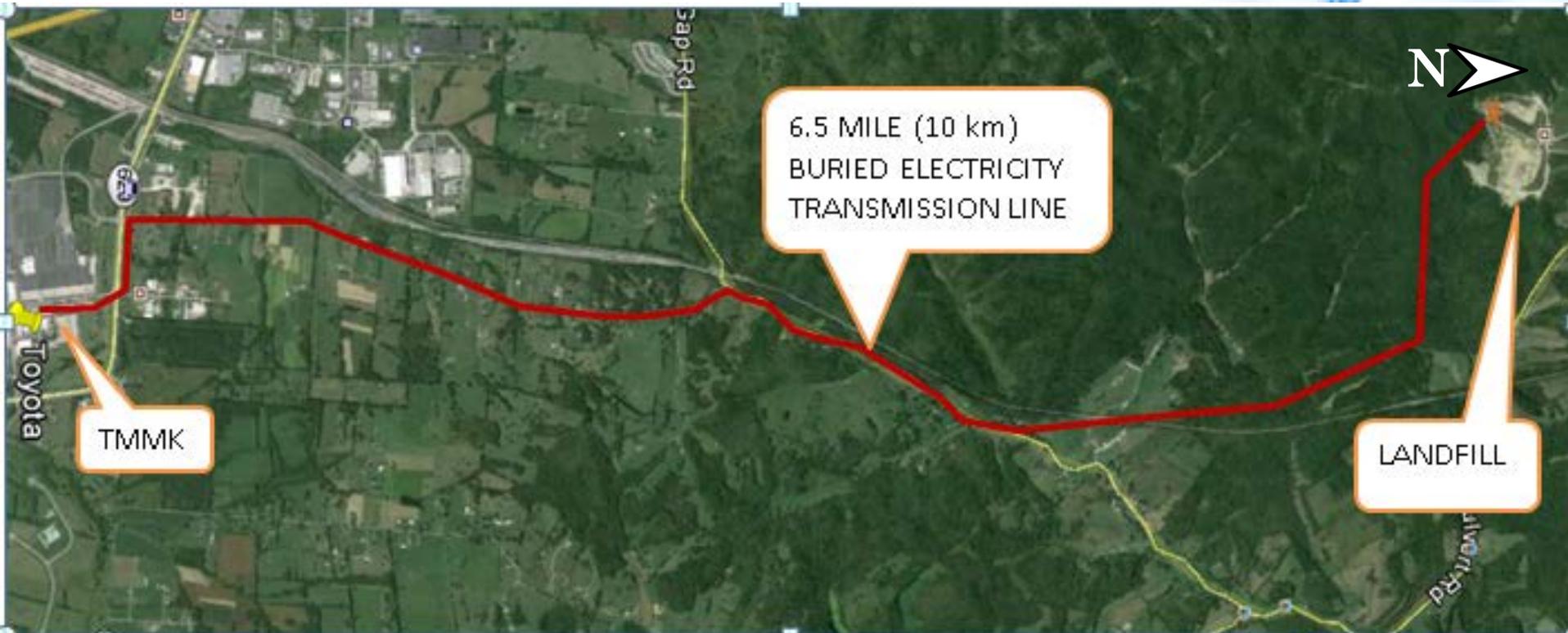
TOYOTA LFG OPTIONS

Options	Pros	Cons
Landfill to collect gas, generate electricity and sell to Toyota	Only change electricity supplier	Electricity regulated in KY, provider must be KU or TMMK Owned generator
Pipe landfill gas to TMMK and generate electric on site	Electricity generation at TMMK	Pipe maintenance & cleaning. Landowners would not allow gas pipe on their land
TMMK to Generate electricity at landfill and transmit to our site	Meets KY electricity generation rules	Equipment at remote location

Contracted with Landfill to operate and maintain our equipment



PATH FROM LANDFILL TO TMMK



Landscape between TMMK and Landfill:

- a. Privately owned – 33 easements obtained
- b. Owners desired underground installation
- c. Very hilly and rocky
- d. Includes public roads, railroads and streams

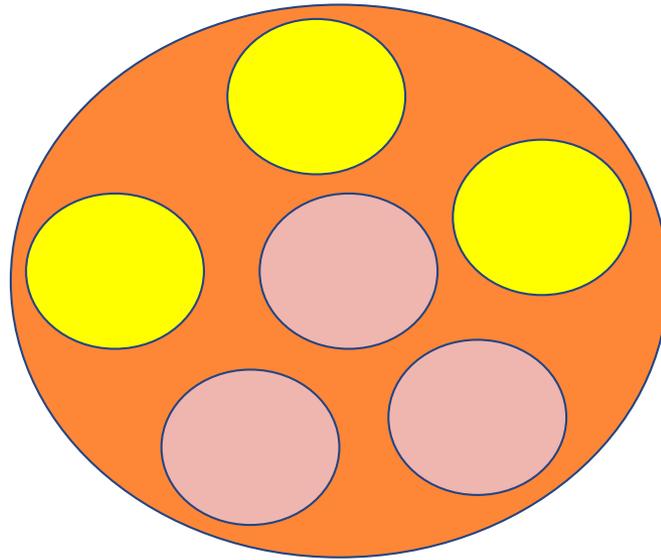
Initial Project Estimates Were Higher than Anticipated

Opportunity to
“Value Engineer”



VE ITEM	DESCRIPTION	BENEFIT	SAVINGS
Cable / conduit	Put cable in conduit at the factory	Separate pulls for conduit & cable becomes one pull for both	50% installation labor reduction
Cable rating	Use 35kV rated cable	3 cables instead of 6. Smaller bore hole (7" vs 12"), Can expand to 10mW	60% cable cost savings
Boring operation	Use air hammer vs. traditional drill bit	600'/day vs. 200'/day (300% improvement in output). 75% reduction in water	56% boring cost reduction
General contractor	TMMK serve as general contractor for project	Reduce sub-contractor markup through direct negotiation	10% project cost savings

TRANSMISSION CIRCUIT DESIGN

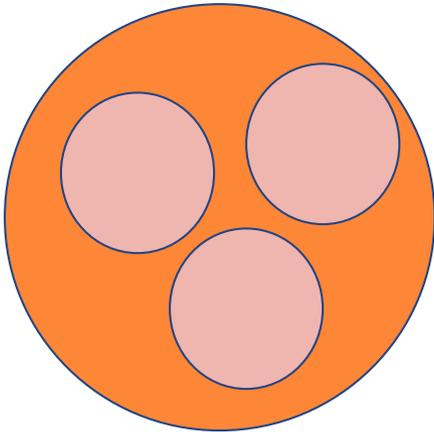


ORIGINAL IDEA:

- a. 12" bore hole
- b. 6 conduits pulled
- c. 15kV wire rating
- d. Pull 3 wires, getting 5mW capacity
- e. Future activity pull 3 more wires for additional 5 mW capacity

NEW TRANSMISSION CIRCUIT DESIGN

KAIZEN



VALUE ENGINEERING:

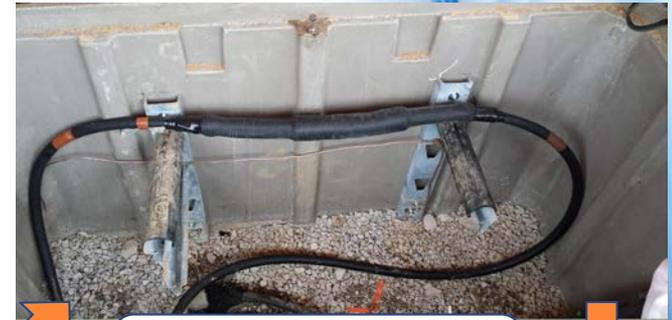
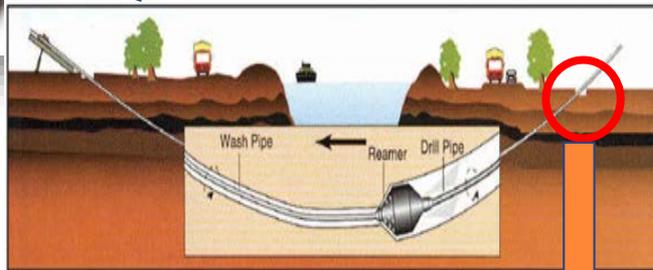
- 7" bore hole
- 3 conduits & wire pulled
- 35kV wire rating
- Initially transmit at 15kV
- Wire in conduit from factory
- After 5mW. Add transformers for 35kV (10 mW capacity)

Savings = 60% from original

DIRECTIONAL BORING INSTALLATION CHOSEN



Let's bore the path for the conduit & wire



WIRE CONNECTION



DIRECTIONAL BORING MACHINE

- o Very little disturbance to the owners land
- o Simplified overall construction of installing the wire

CONSTRUCTION PICTURES



AIR HAMMER DRILL
BORING



TRENCHING



WIRE MANHOLE



CABLE & WIRE

CONSTRUCTION PICTURES CONTINUED



LANDFILL GAS WELLS



OFFICE



GENERATOR



GAS VACUUM EQUIP

COMPLETED LFG SITE

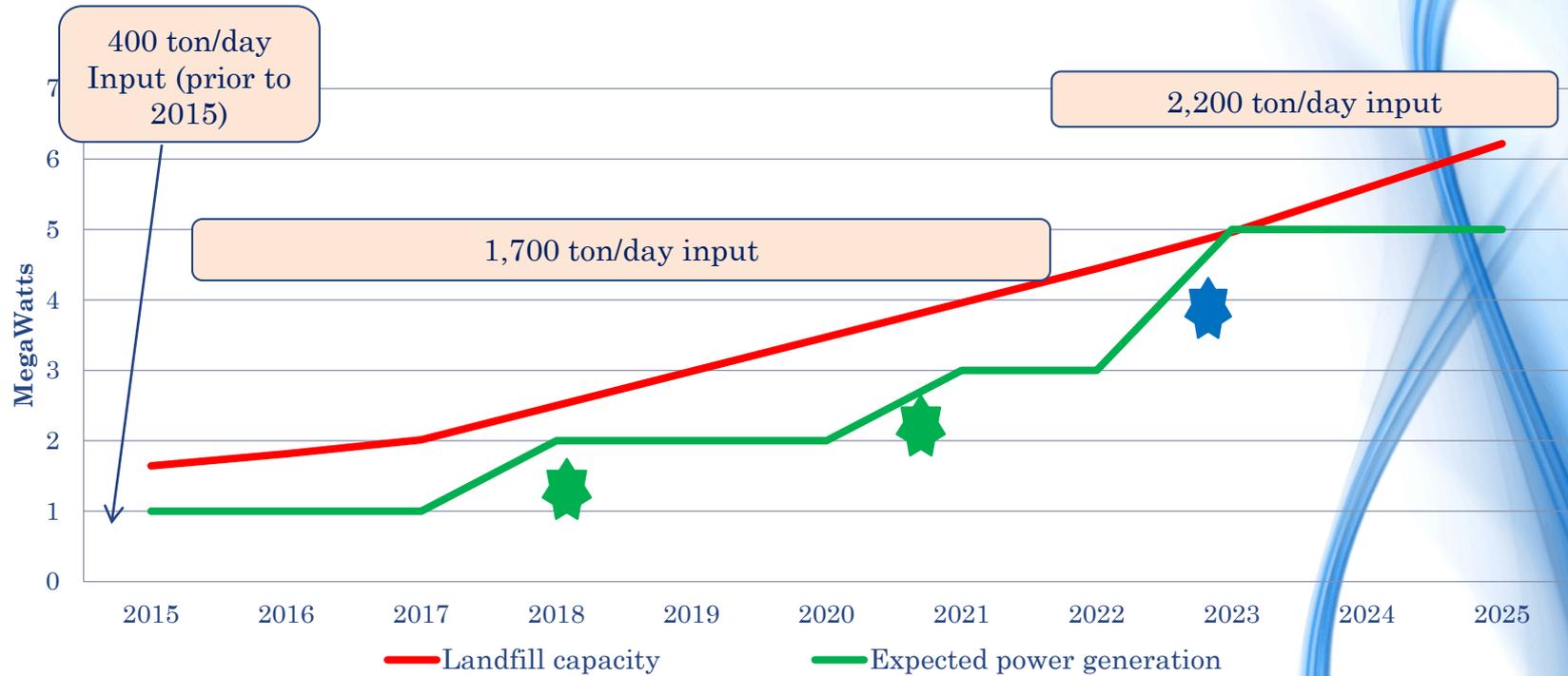
1 mW GENERATOR
480 V, 3PH

SUPPORT SHOP/
OFFICE

3 mW TRANSFORMER
480 V, 3PH TO 13,800 V, 3PH

LANDFILL GAS VACUUM
/ PRESSURIZATION SKID

THE FUTURE OF LANDFILL GAS AT TMMK



★ Additional 1mW generator unit

★ Additional 2mW generator unit

- Based on US Landfill Gas Model - landfill gas output lags waste input by ~ 3 yrs
- Landfill waste is expected to support up to 5 mW by 2025

LEARNING POINTS

1. Project took longer to complete than anticipated
2. Gaining approval from private/public sector is very relationship driven which takes time to develop
3. Understand local government ordinances
4. Understand local environmental issues for construction
5. Working with a partner vs. a supplier was a different situation for TMMK as well.
6. Ensure all expectation and goals are understood from all parties
7. Flexibility is key
8. Plan for the unexpected

THANK YOU



Q & A