ENERGY PLANNING CONSIDERATIONS FOR SAN JOSE WATER POLLUTION CONTROL PLANT

IDEA 2014

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Based on Paper by Arvind Akela

CDM Smith

February 19, 2014

LADIES AND GENTLEMEN

ATTENTION

Objectives

I. Assessment of Existing Conditions
II. Supply-demand Analysis
III. Standby Power Analysis
IV. Proposed Combined Heat and Power System
V. Air Permit Implications
VI. Life Cycle Cost Analysis
VII. Implementation Plan

I. ASSESSMENT OF EXISTING CONDITIONS

Energy Management Improvement Triggers

- Client wants 100% self generated, reliable power generation
- Equipment condition
- Operation and Maintenance (O&M) cost on existing systems
- Stricter regulatory requirements
- Future power demand increase

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Assessment of Existing Conditions
Engine-Driven Generators: P&E Building

Pump and Engine Building Engine-Driven Generators												
				Power	Bore	Stroke	Speed	Generator Rated	Stack Ht	Fuel Input	Emission Limits at 15% O_2	
Unit Name	Make and Model	Year Built	Start-up Date	BHP	inch	inch	RPM	kW	ft	MMBtuh	CO, ppm	NO_x, ppm
E - 1	Enterprise DGSG8-CB	1953	1956	1,130	12	15	514	800	45	9.1	2,000	140
E - 2	Enterprise DGSG8-CB	1953	1956	1,130	12	15	514	800	45	9.1	2,000	140
E - 3	Enterprise DGSG8-CB	1953	1956	1,130	12	15	514	800	45	9.1	2,000	140
E - 5	Enterprise DGSR8-CB	1962	1963	2,466	17	21	360	1,750	47.5	20.9	2,000	140
E - 6	Enterprise DGSR8-CB	1962	1963	2,466	17	21	360	1,750	47.5	20.9	2,000	140

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E-5, E-6 Decrease Plant's Power Reliability

- **E-1 / E-2 / E-3 (1953)**
  - E-1 retired
  - E-2/E-3 operational, used often
- **E-5 (1962)**
  - Cracks on engine blocks
  - Being used as backup for EG-3 until parts are available
- **E-6 (1962)**
  - Retired

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Assessment of Existing Conditions
Engine-Driven Generators: Building 40

Generator Blower Building (Building 40) Engine-Driven Generators												
Unit Name	Make and Model	Year Built	Start -up Date	Power	Bore	Stroke	Speed	Generator Rated	Stack Ht	Fuel Input	Emission Limits	
				BHP	inch	inch	RPM	kW	ft	MMBtuh	CO, lb/d	NO_x, g/bhphr
EG - 1	Cooper Bessemer	1994	1995	3,900	15.5	22	400	2,800	44.5	28.9		1.0
EG - 2	Enterprise-Delaval HVA - 16	1983	1985	3,900	14	15	600	2,800	43.5	30	413.4	1.8
EG - 3	Enterprise-Delaval HVA - 16	1983	1985	3,900	14	15	600	2,800	23	30	413.4	1.8

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Plant Power Reliability Issues

- **EG-1 (1994)**
  - One of the main sources of power
  - ~110,000 hrs. of operation
  - Requires bearing maintenance
  - Unexpected tripping recently
- **EG-2 (1983)**
  - General conditions wear and tear
  - Temperature issues

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Plant Power Reliability Issues

- **EG-3 (1983)**
  - Shut down since April 2010
  - Parts no longer available

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Existing Conditions of Driven Equipment
High Power Consuming: Engine-Driven Blowers

Secondary Blower Building Engine-Driven Blowers`										
Unit Name	Make and Model	Year Built	Start-up Date	Power	Bore	Stroke	Speed	Fuel Input	Emission Limits at 15% O_2	
				BHP	inch	inch	RPM	MMBtuh	CO, lbs./d	NO_x, g/bhphr
A - 1	Cooper Bessemer LS-8-SGC	1962	1963/64	2,345	15.5	22	330-360	19.9	2,000	140
A - 2	Cooper Bessemer LS-8-SGC	1962	1963/65	2,345	15.5	22	330-360	19.9	2,000	140
A - 3	Cooper Bessemer LS-8-SGC	1962	1963/66	2,345	15.5	22	330-360	19.9	2,000	140
B - 1	Cooper Bessemer LS-6-SGC	1962	1963/67	1,855	15.5	22	330-360	15.7	2,000	140
B - 2	Cooper Bessemer LS-6-SGC	1962	1963/68	1,855	15.5	22	330-360	15.7	2,000	140
B - 3	Cooper Bessemer LS-6-SGC	1962	1963/69	1,855	15.5	22	330-360	15.7	2,000	140

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Existing Conditions, Driven Equipment
Electric Blowers

Building 40 Electric Motor-Driven Blowers				
Unit Name	Year Built	Make	Type	Power (Hp)
EB – 1	1983	Dresser Roots	Single Stage	4,000
EB – 2	1983	Dresser Roots	Single Stage	4,000
EB – 3	1983	Dresser Roots	Single Stage	4,000

Nitrification Blowers				
Unit Name	Year Built	Make	Type	Power (Hp)
Blower 1	1986	Dresser Roots	Multistage Centrifugal	2,250
Blower 2	1986	Dresser Roots	Multistage Centrifugal	2,250
Blower 3	1986	Dresser Roots	Multistage Centrifugal	2,250
Blower 4	1986	Dresser Roots	Multistage Centrifugal	2,250
Blower 5	1986	Dresser Roots	Multistage Centrifugal	2,250

Assessment of Existing Conditions

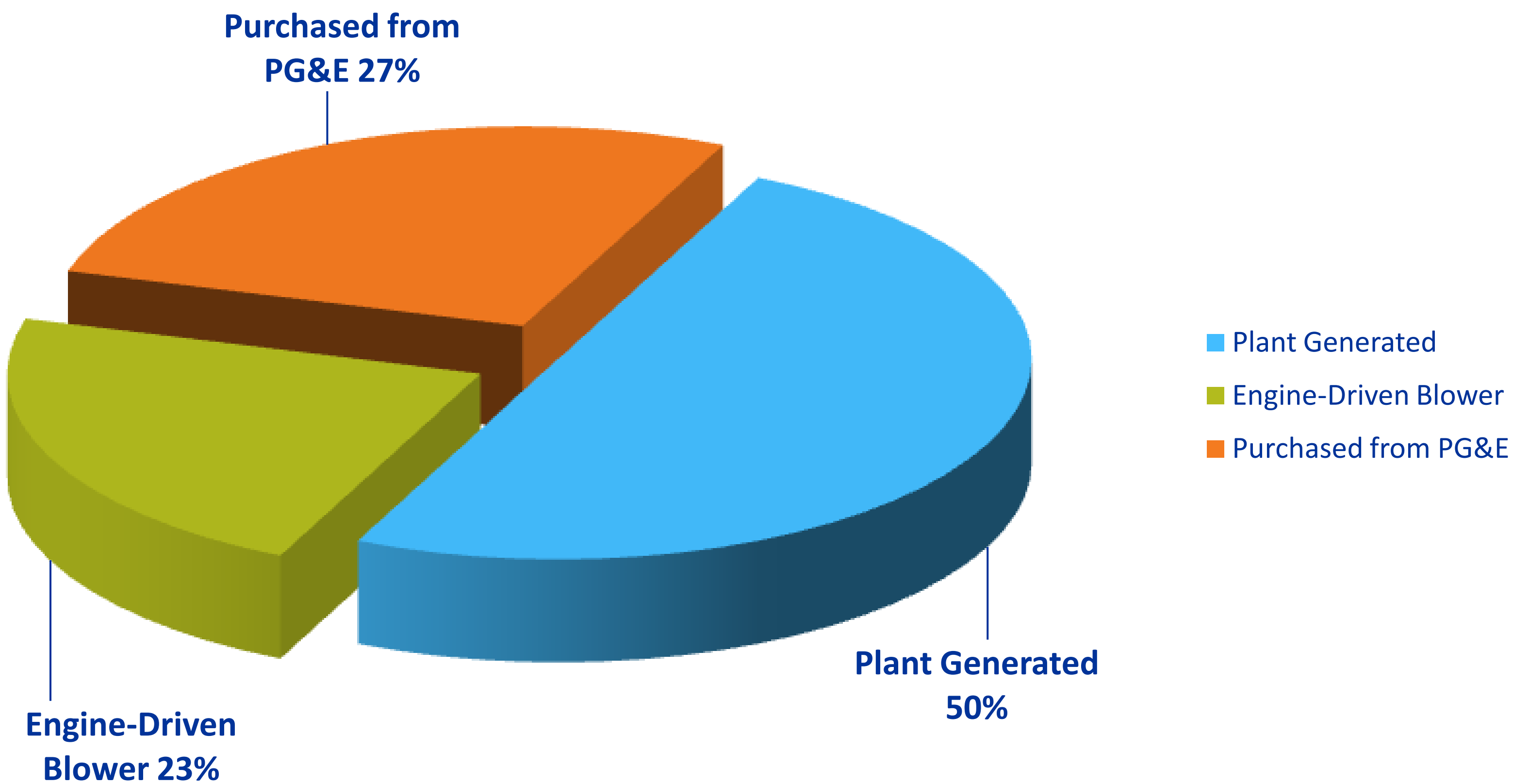
- Condition assessment of major power and air equipment occurred in parallel
- CDM Smith performed condition assessment as part of a separate agreement

II. SUPPLY VERSUS DEMAND ANALYSIS

Baseline Determination

- 2010 data used as baseline
- Actual data obtained from the plant

2010 Annual Average Power Supply



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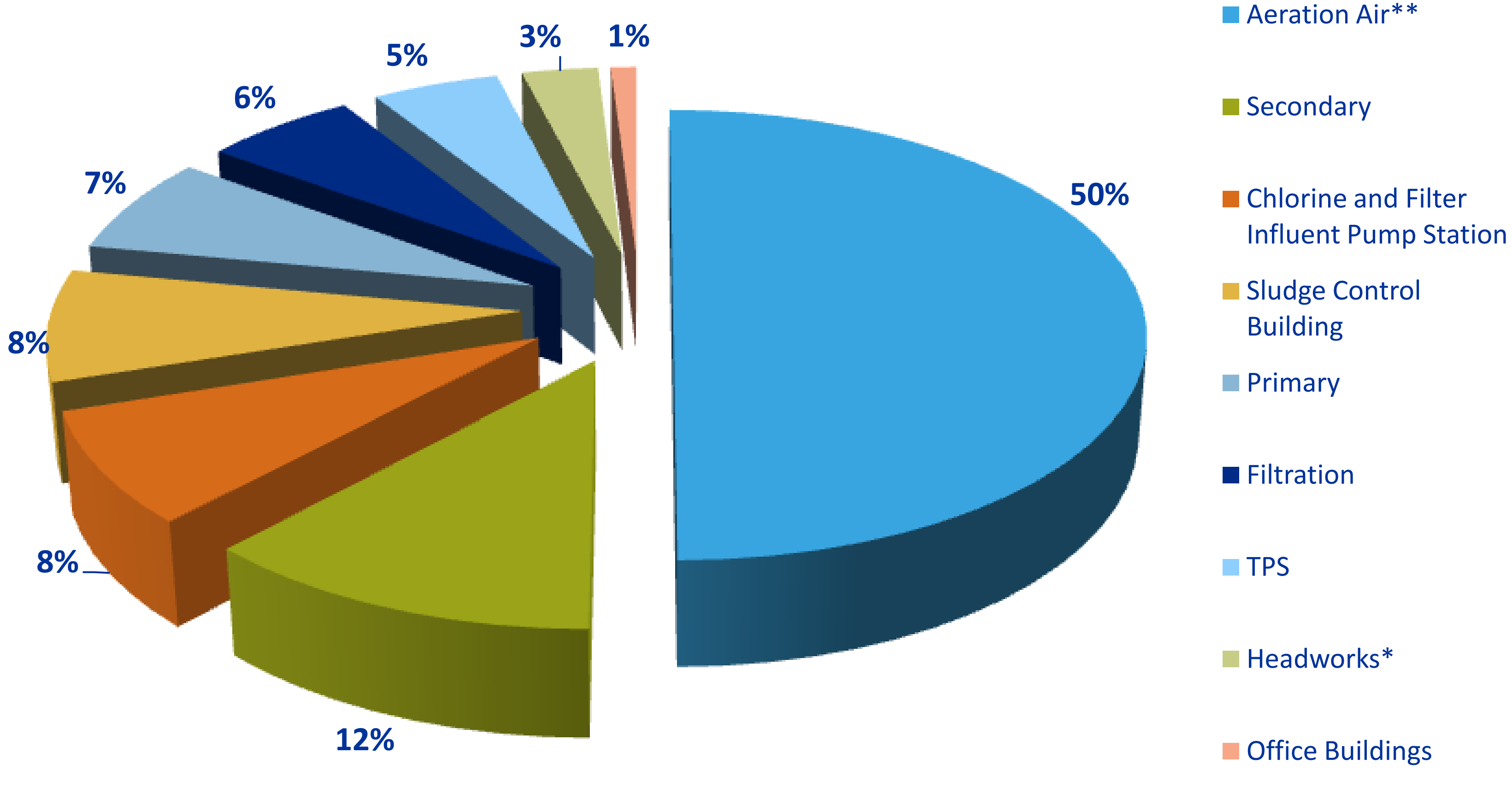
2010 Annual Average Power Demand



** In the absence of old headworks power demand data, an average of 250 kW demand has been assumed. New headworks has not operated in 2010, so there is only an average of 50kW power demand that comes from MCC.*
*** Aeration air demand includes demand from both BNR 1 and BNR 2.*

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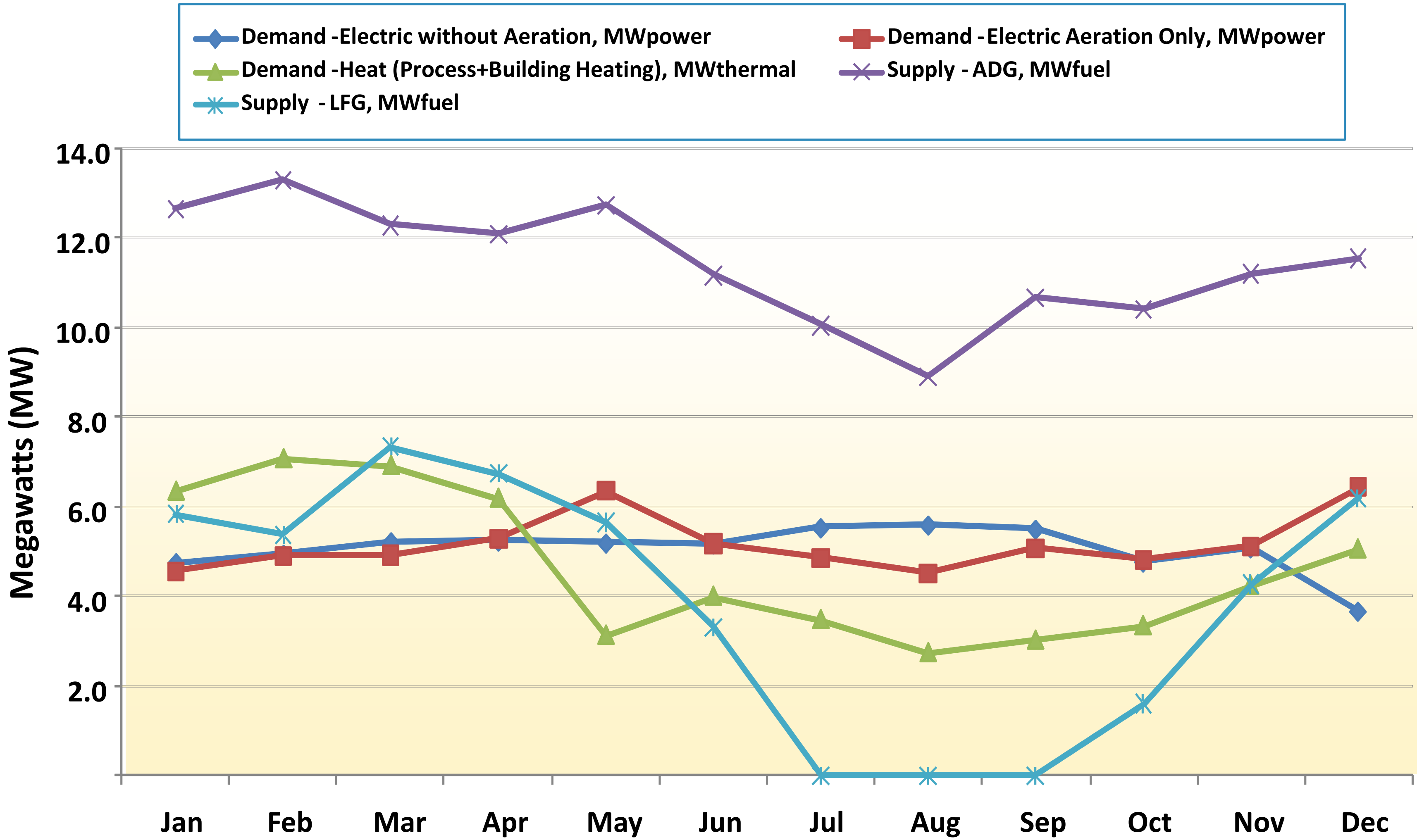
2010 Summary Energy Profile



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Basis of Projection

- Year 2010 data
- Plant master plan documents
  - Pm 5.3 energy evaluation
  - Pm 3.8 projected wastewater flows and characteristics
  - Tm 4.3 heating system upgrades
- Off-gas testing report (Professor Michael Stenstrom)
- Heat balance study (CDM Smith)

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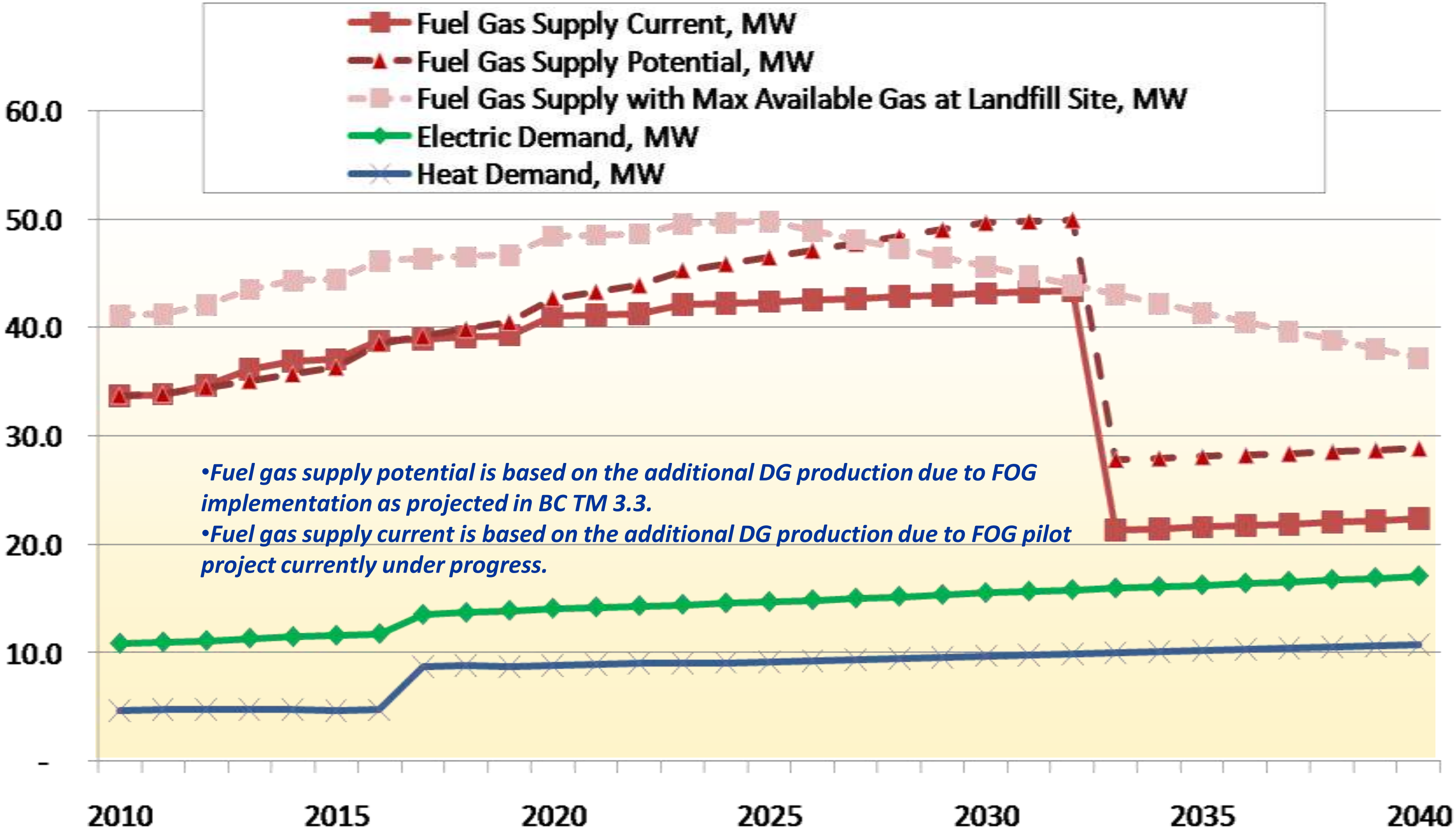
Projections: Gas, Electric, and Heat



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Supply Side Alternatives

- Technology selections
  - Fuel cell
  - Gas turbine
  - IC engine
- Transitional plan for
  - Existing engine-driven generators
  - Existing engine-driven blowers
  - Absorption chillers
  - Steam boilers

Final Proposed Scenarios with Phasing

Scenario 1	Scenario 2	Scenario 3
(1) New Fuel Cell	(1) New Fuel Cell	(1) Fuel Cell
(2) New Gas Turbines	(2) New Gas Turbines-Phase 1	(3) Gas Turbines-Phase 1
	(1) New Gas Turbines-Phase 2	
Existing equipment with transitional plan	Existing equipment with 10-year transitional plan	Existing equipment with transitional plan
		

Source: www.memagazine.org/.../changing/changing.html

III. STANDBY POWER ANALYSIS

Total Power Demand

	2010	2015	2025	2040
Plant Flow (MGD)	111	117	131	153
Current Electric Demand (MW) – without aeration	5.0	5.5	6.0	7.1
Future Electric Demand (MW) – without aeration	0.0	0.0	1.8	2.0
Aeration Electrical Demand (MW)	5.8	6.1	6.9	8.0
Total Power Demand (MW)	10.8	11.6	14.7	17.1
Critical Power Demand (MW)	4.6	5.0	5.8	6.7

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Load Analysis for Full Secondary Treatment

- Less conservative design practice (with limits on operation)
  - Start the critical load first
  - Start two large 4,000hp blower next
  - Start limited additional smaller loads last

- More conservative design practice (to ensure largest load can always be started)
  - Start the critical load first
  - Start smaller loads next for full operation except blowers
  - Start the two 4,000hp blowers last

Standby Power Recommendations

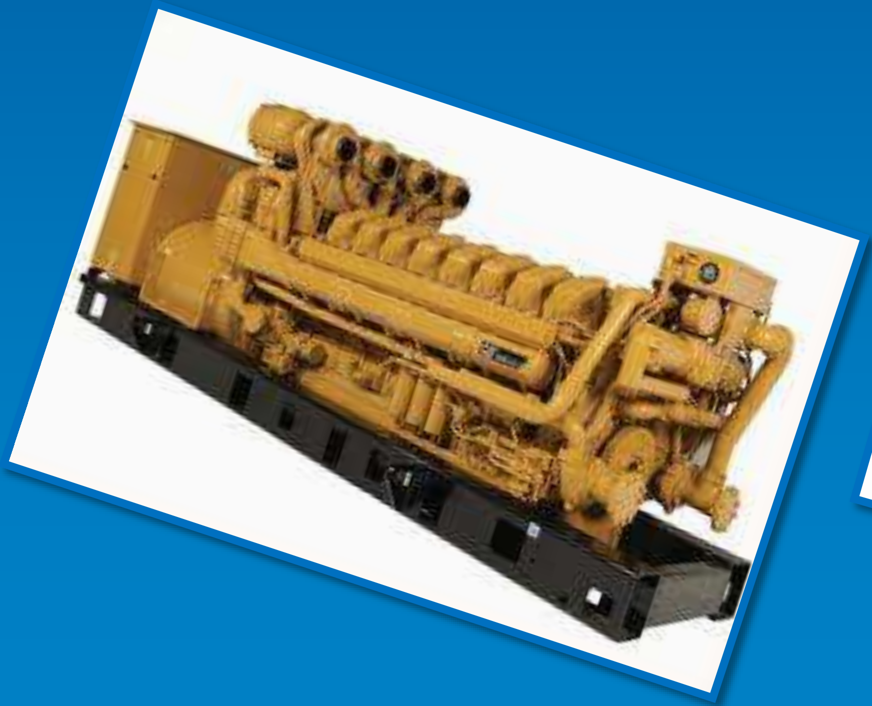
- Install 9MW of diesel power
- Two new 3MW diesel generators
- Modify EG-1 cooling system to use as standby power capacity
- Replace EG-1 with in-kind at the end of its useful life

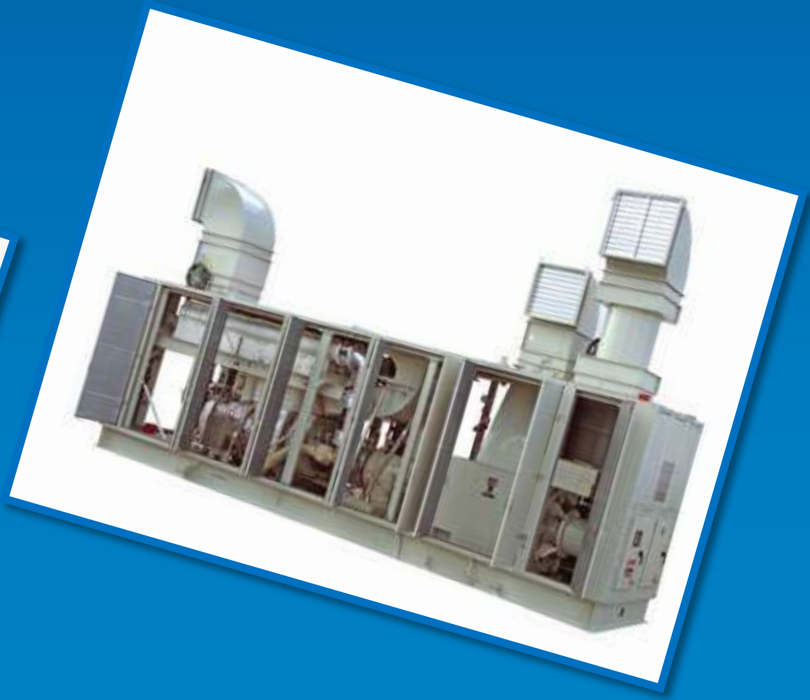
(New 3MW) (New 3MW) (Existing EG-1)

+

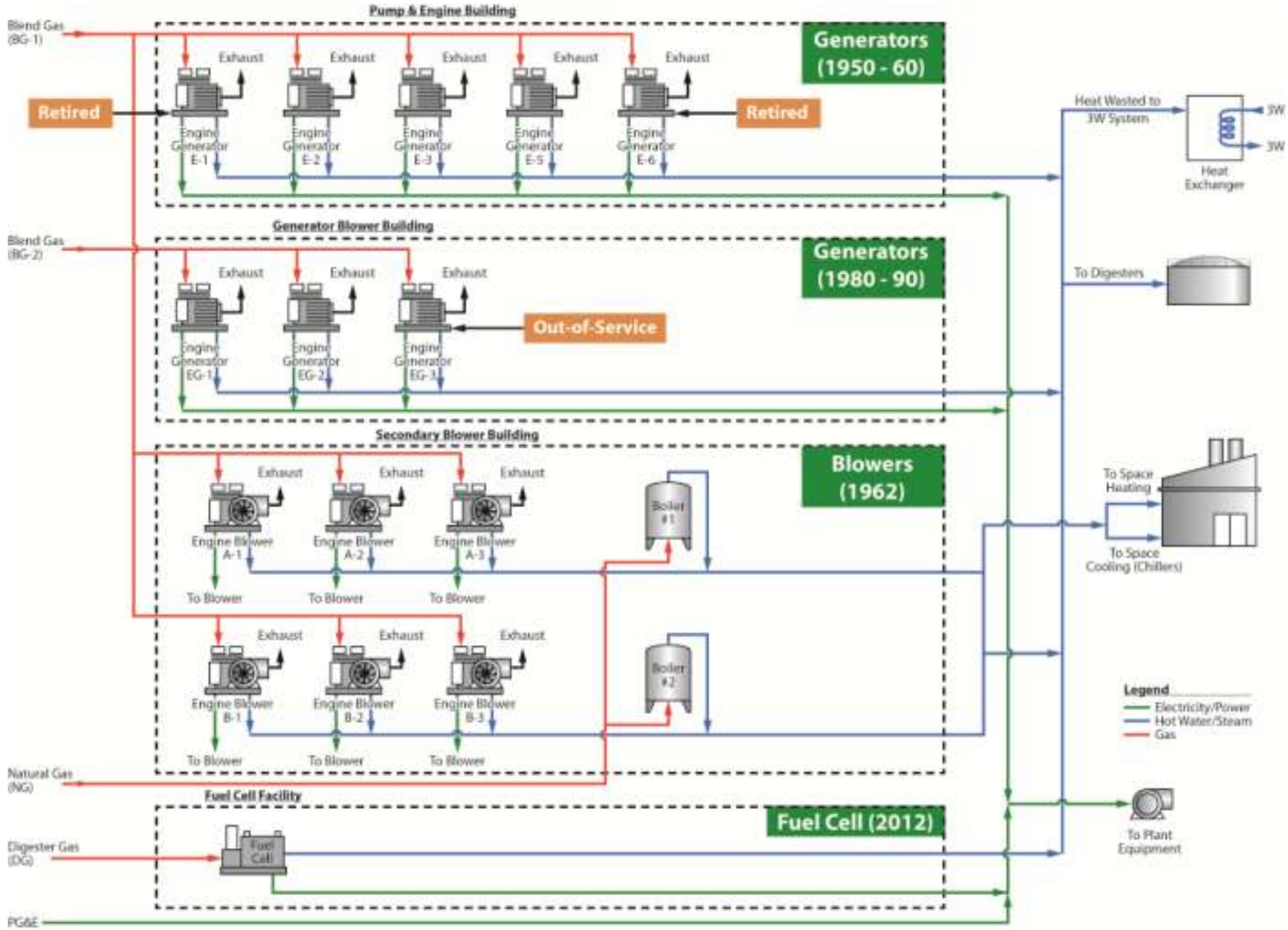
+

IV. PROPOSED COMBINED HEAT AND POWER SYSTEM





Energy Flow Diagram – Current



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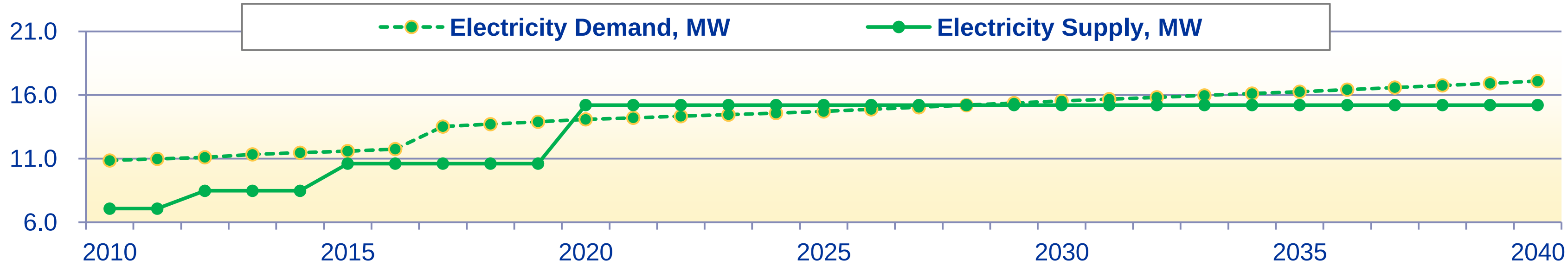
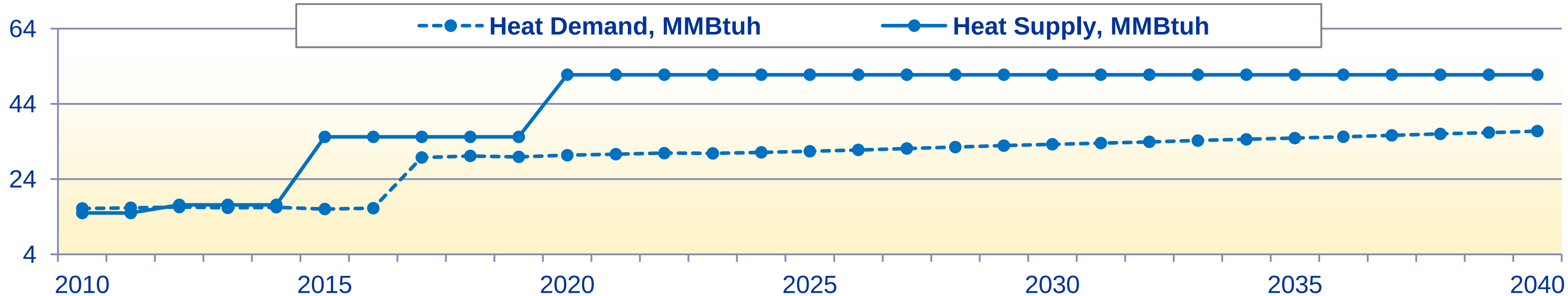
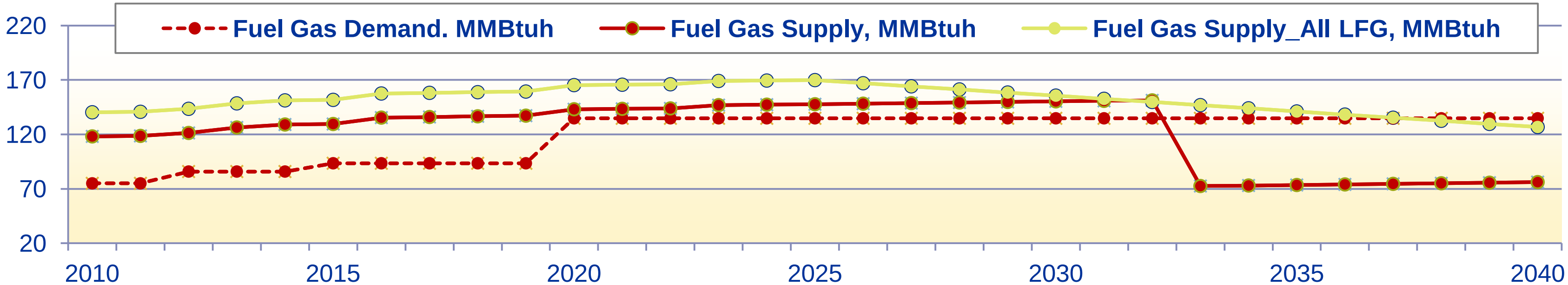
Long Term Energy Profile





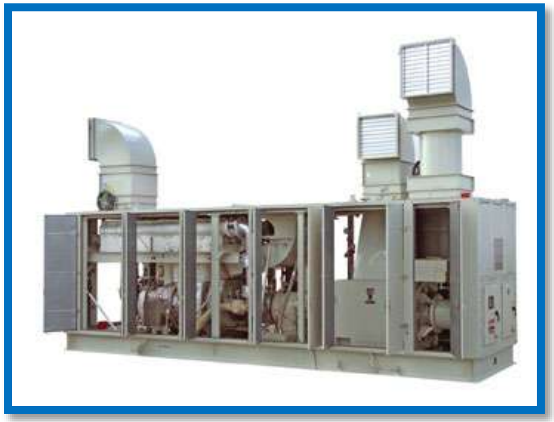


1. Fuel Gas Supply considers only one 15-year term renewal of existing contract.
2. Fuel Gas Supply All LFG considers entire gas available at landfill site.

V. AIR PERMIT IMPLICATIONS

Emission Standards for Gas Turbines

POLLUTANT	Bay Area AQMD BACT Emission Limits
NOx	23 ppm*
CO	100 ppm*
SO_2	150 ppm
* Emission limits are 15-minutes average	
All concentrations are corrected to dry at 14% O_2	



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Emission Comparison Between Building 40 Engines and Gas Turbines

Existing Engines	NOx (g/bhp-hr)	CO (g/bhp-hr)	VOC (g/bhp-hr)
EG-1	0.58	1.84	0.24
EG-2	0.48	1.90	0.23
EG-3	0.53	2.00	0.07
Average	0.53	1.91	0.18
Based on recent test data provided by the City			

Gas Turbines	Nox (g/bhp-hr)	CO (g/bhp-hr)	VOC (g/bhp-hr)
Gas Turbine	0.33	0.40	0.02
Based on emission data provided by the solar manufacturer of Mercury 50			

Emission Reduction for 13.2 MW Of Generation

- A detailed plant wide emission reduction calculation to be done at the time of permit application

	Unit	NOx	CO	VOC
Existing Gas Engines	g/hr	9,355	33,828	3,207
New Gas Turbines	g/hr	5,849	7,126	406
Emission Reduction Rate	g/hr	3,505	26,702	2,801
Annual Emission Reduction	ton/year	34	258	27

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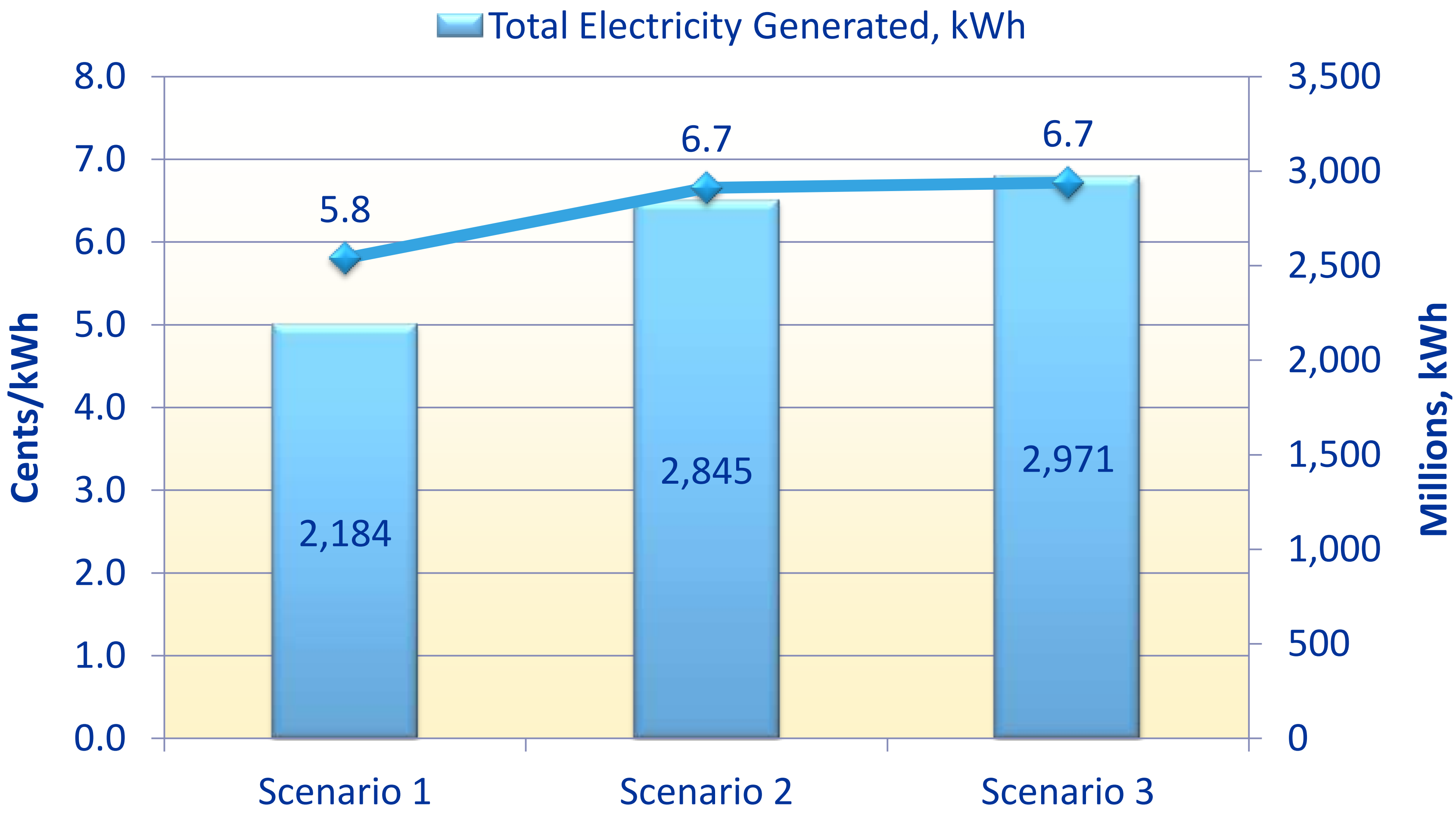
VI. LIFE CYCLE COST ANALYSIS

Total Electricity Generated (30-year period)



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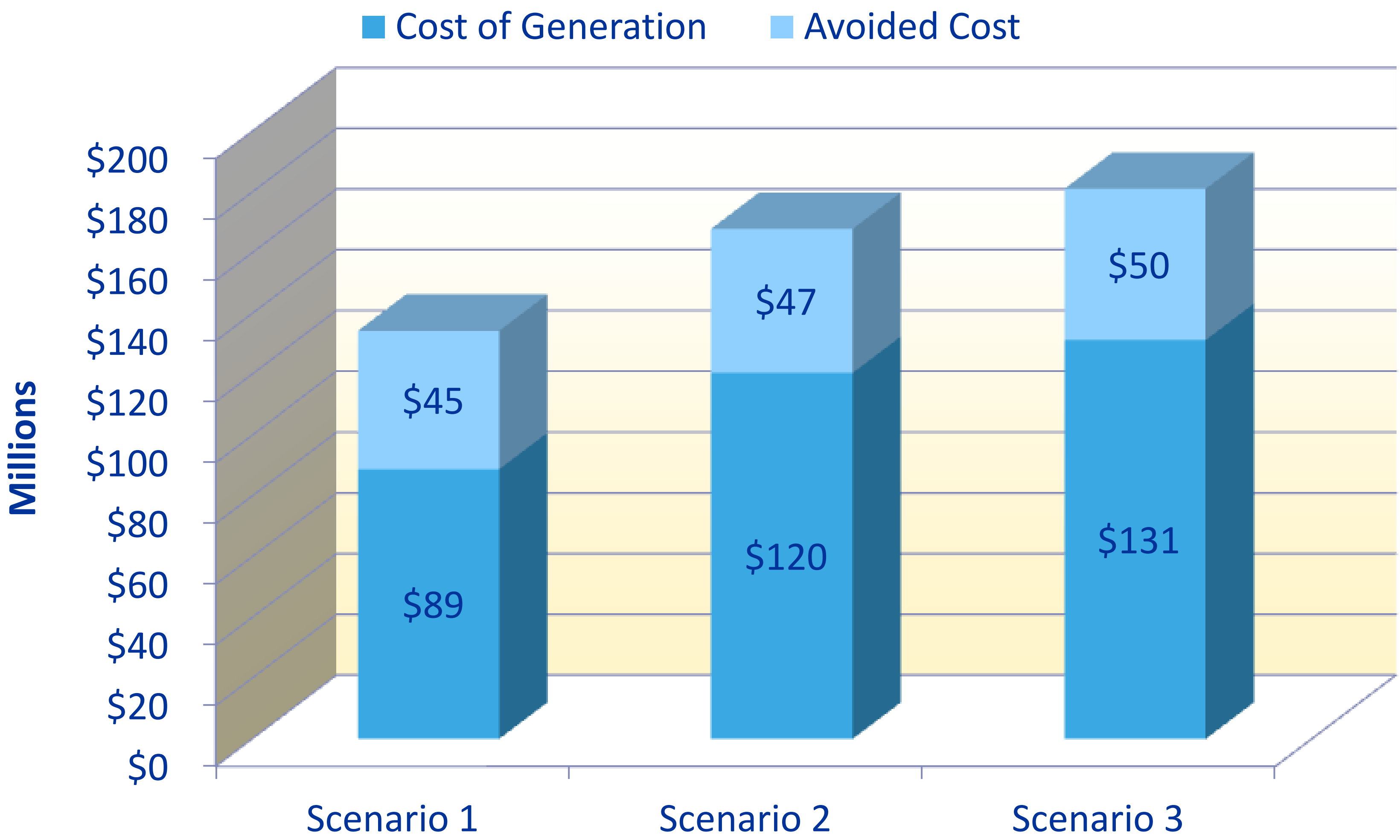
Value of Electricity Generated (30-year period)



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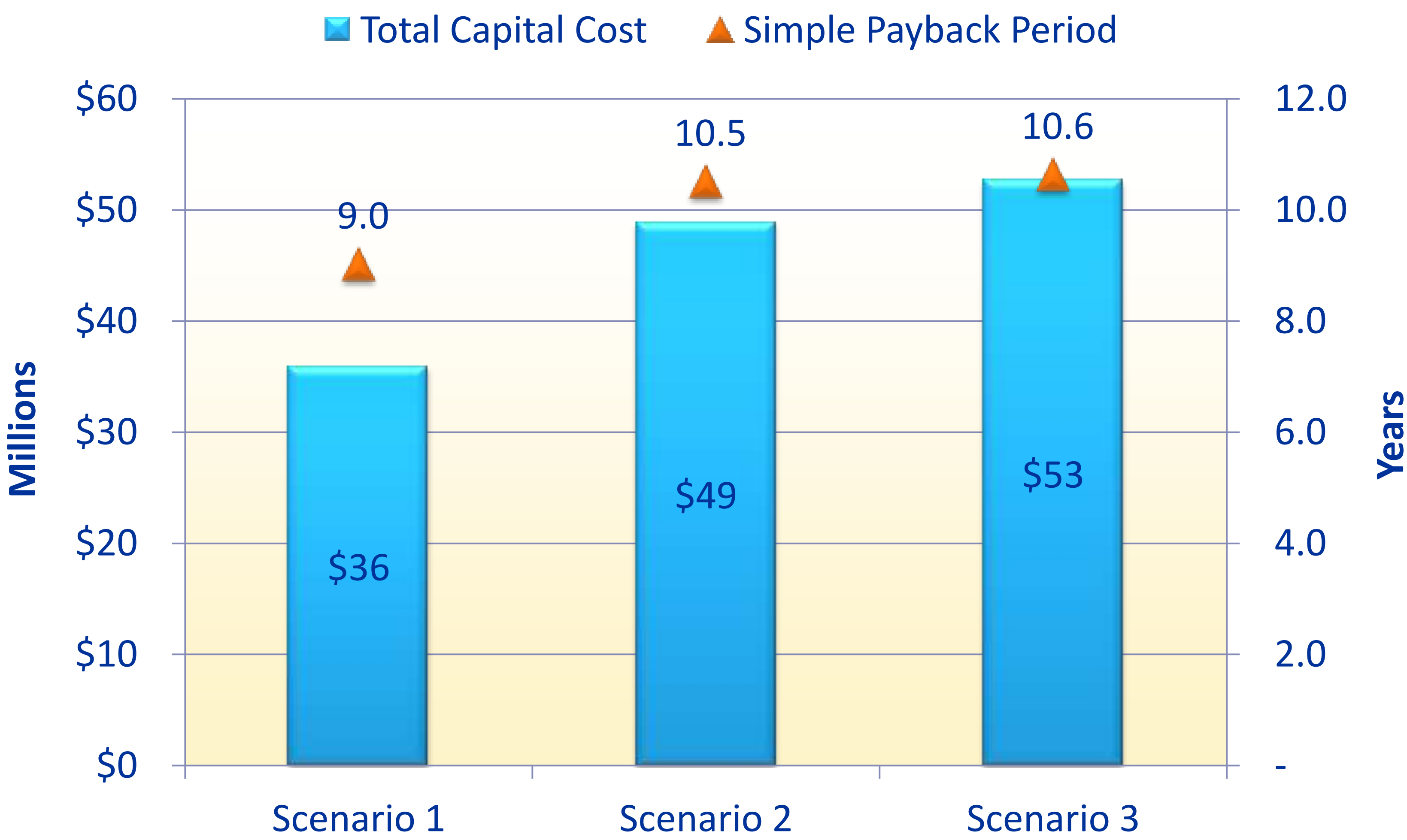
Simple Payback



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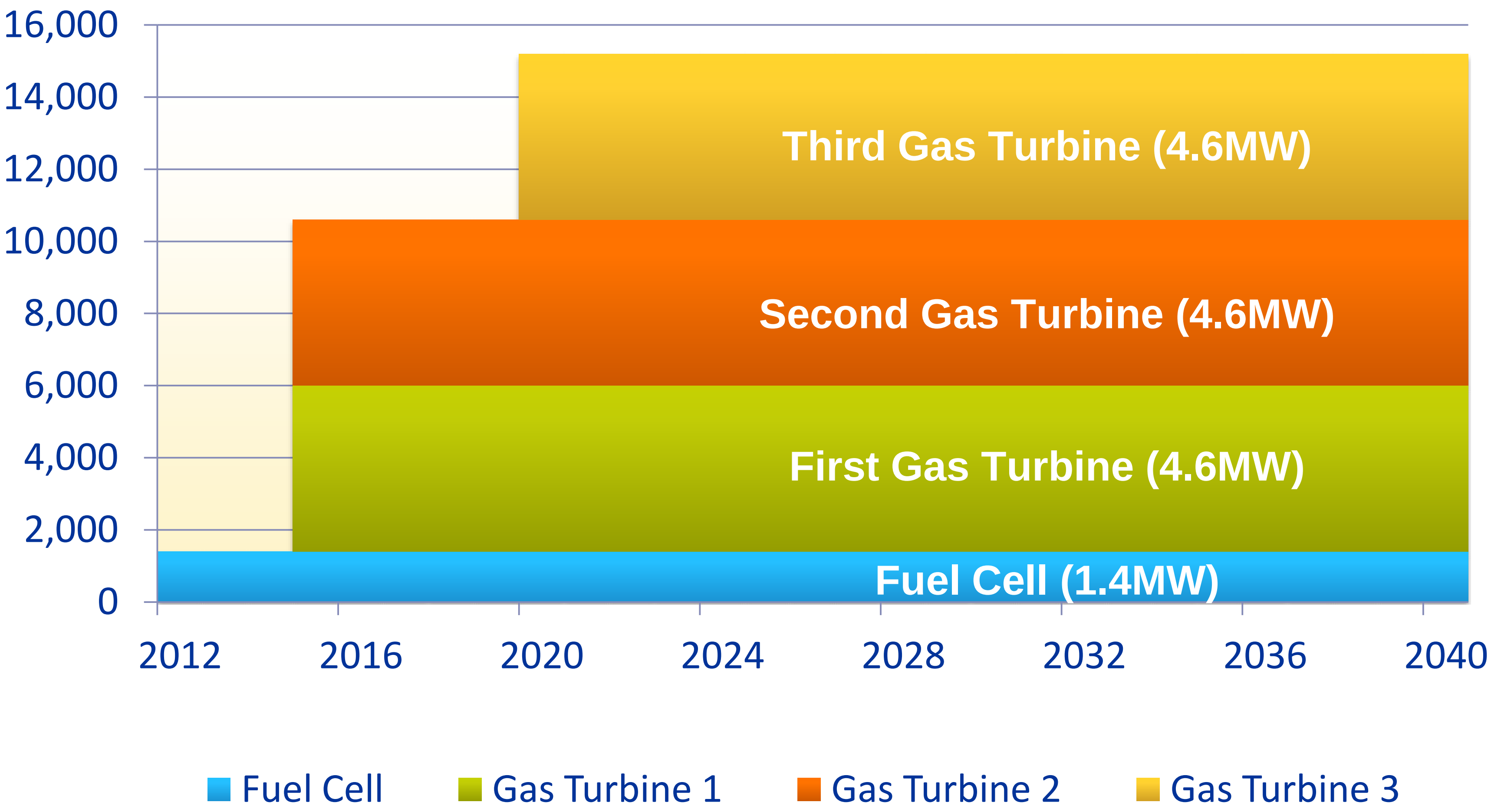
VII. IMPLEMENTATION PLAN

Timeline for Gas Turbines



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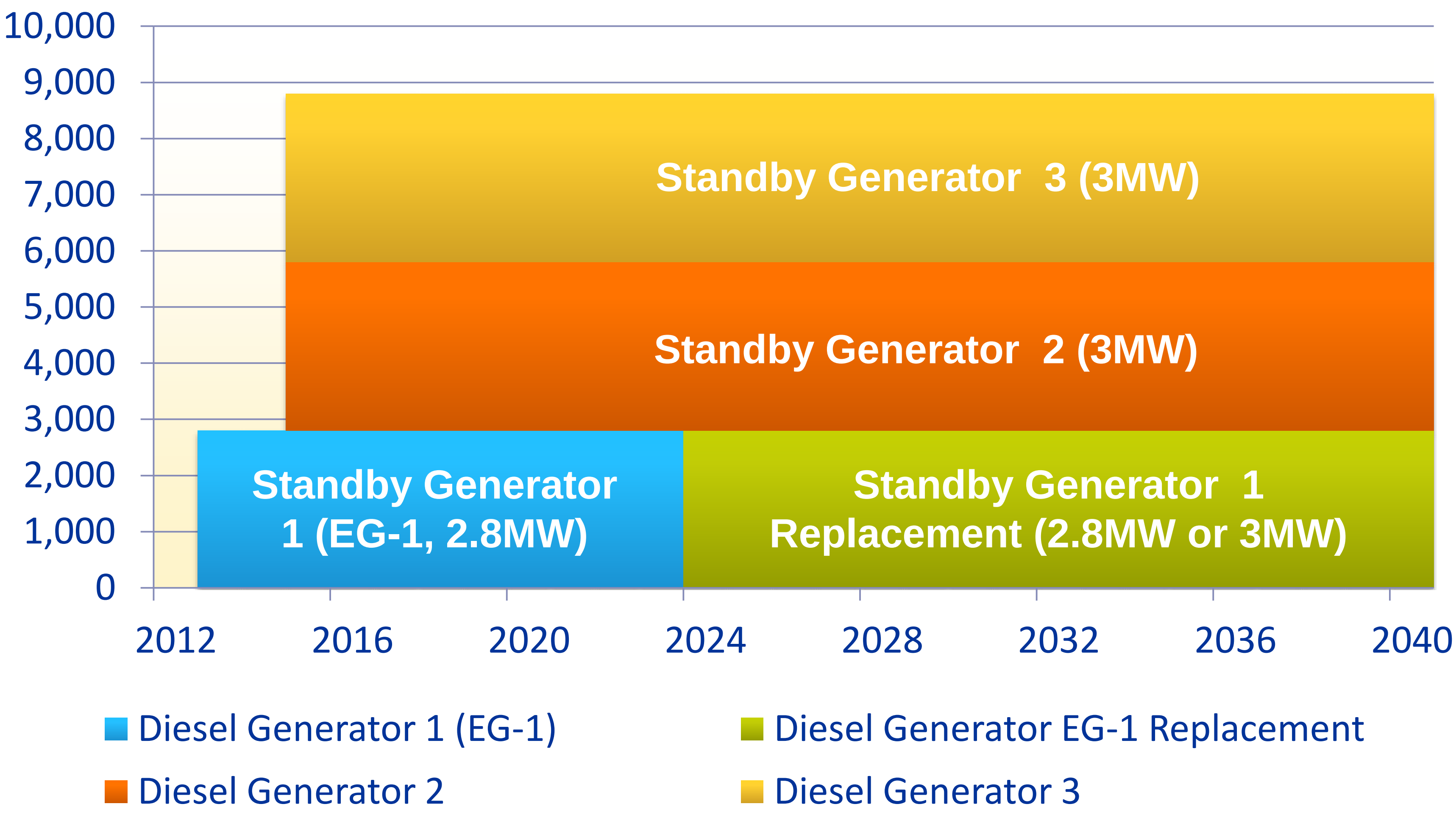
Timeline for Standby Generators



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Total Capital Cost

Construction Components	Phase 1 Cost (millions)	Phase 2 Cost (millions)	Comments
Cogeneration System	$41	$14	Phase 1 – Two gas turbines Phase 2 – One gas turbine
Gas Treatment System	$10		Install capacity for final build out in Phase 1
Standby Power System	$8		Two new diesel generators & EG-1 modified for black start
Total Capital Cost	$59	$14	Total capital cost $73 million

Summary

- New Cogeneration Facility
  - Total three (4.7 MW) gas turbines in two phases
  - Outdoor gas treatment system purchase enough to handle all (3) gas turbines
- New Standby Generator Facility
  - Indoor/outdoor
  - Total three (3 MW) diesel generators in two phases to get 9MW of standby capacity
- Air Permit Implications
  - Start permit application early
  - Requirements: emission calculations, HRA, and air permit
- Implementation Plan
  - Timeline for gas turbines and standby generators
  - Approximately $73 million capital

Questions/Comments/Discussions

The sewer is the conscience of the city. Everything converges and confronts everything else. In that livid spot there are shades, but there are no longer any secrets. The sewer is a cynic. It tells everything!

Robert Dawson
Professional Photographer

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