



Iterating Gas and Power Models

GPCM Power Model Interface

November 2024

The Leader in Energy Market Simulation Systems

Providing energy companies, consultants, and regulators advanced tools to support:

- Investment and M&A Strategy
- Environmental and Sustainability Goals
- Credible Risk Analysis
- Trading Strategy
- Policy Development and Assessment
- Energy Security

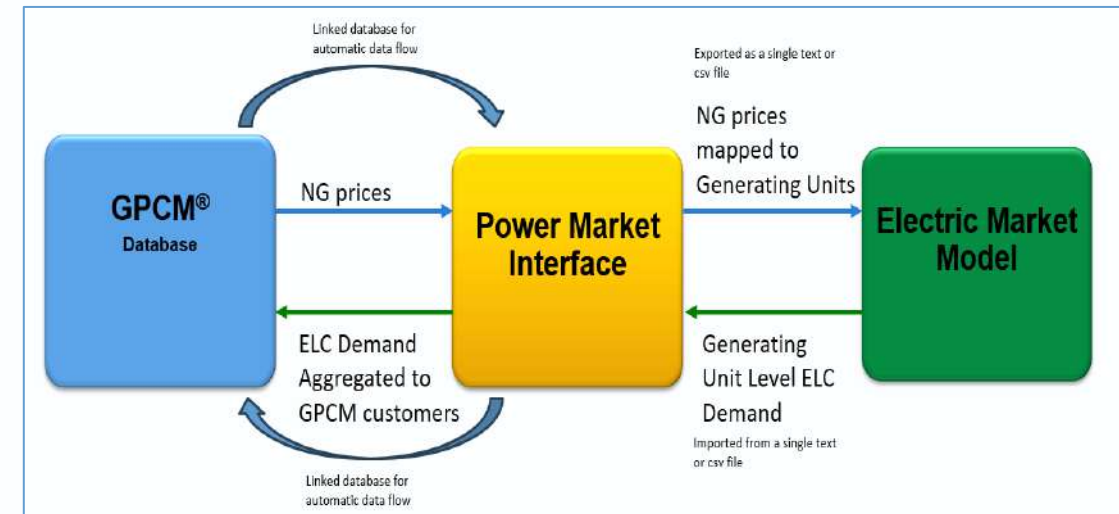
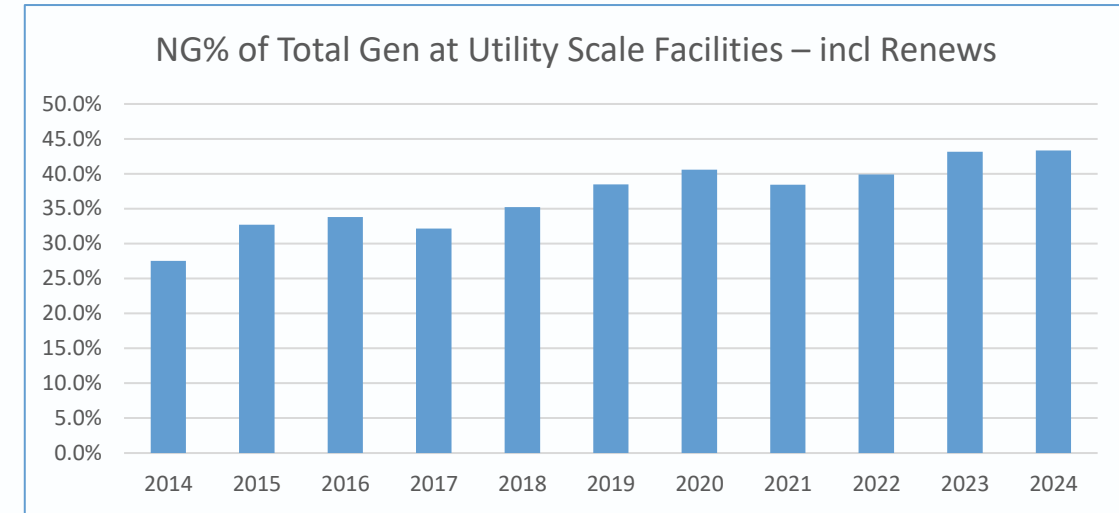
Topics Covered

Natural Gas Increasing share of fuel generation

Why Iterate Power and Gas Model?

How to Model Interrelated Gas and Power Markets

GPCM and RBAC's Power Model Interface (PMI)



Demand has been growing steadily



Units: Terawatt Hours

- Natural Gas **production** has increased significantly in the last decade
- **Low prices** due to abundant supply
- **Increased demand** for natural gas in the Electric Generation sector

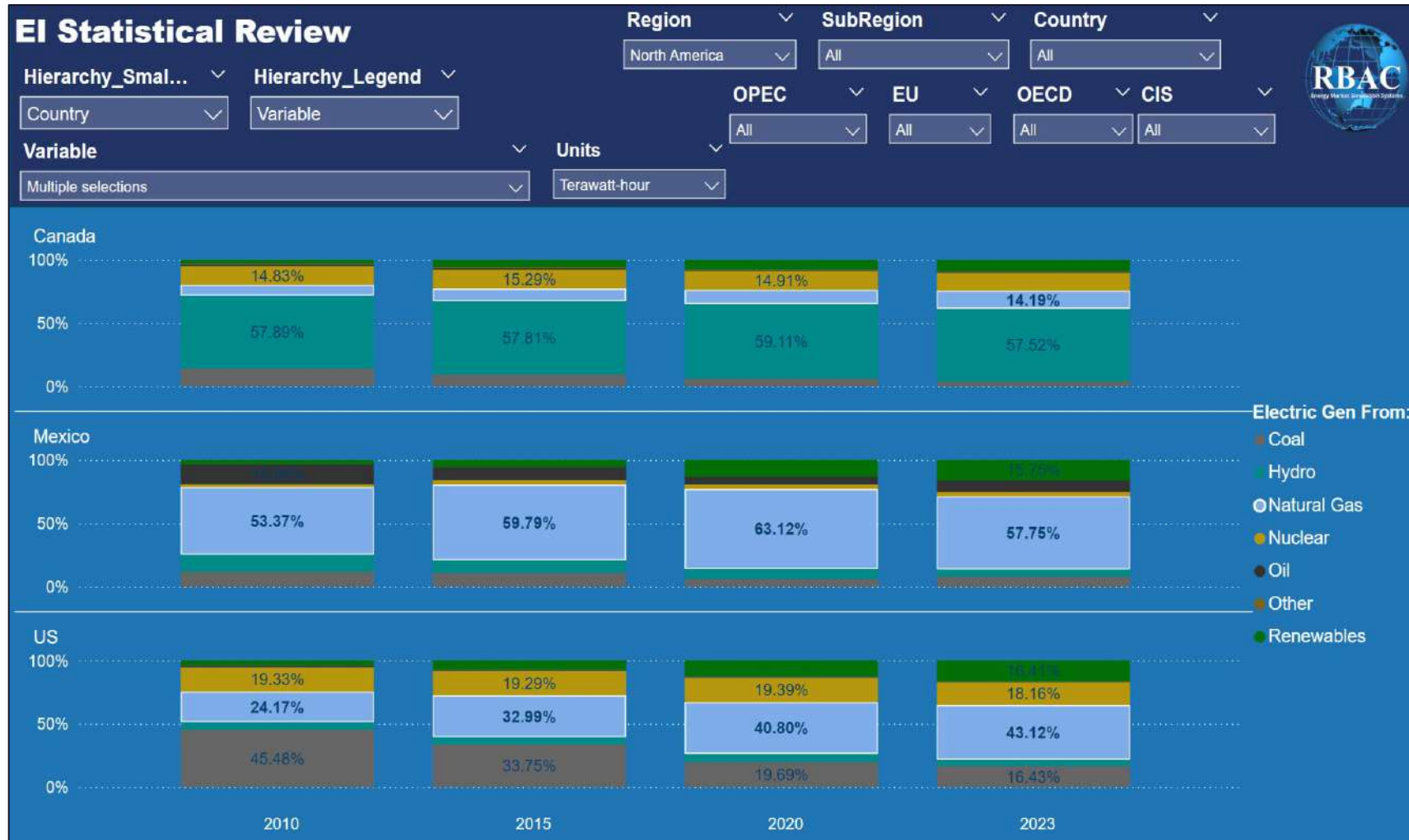
Cheaper and More Environmentally Friendly



Units: Share of Market

- Amongst fossil fuels, natural gas share of the market has grown
- Coal as a fuel has dropped
- The market shifts impact both the electric generation and natural gas markets

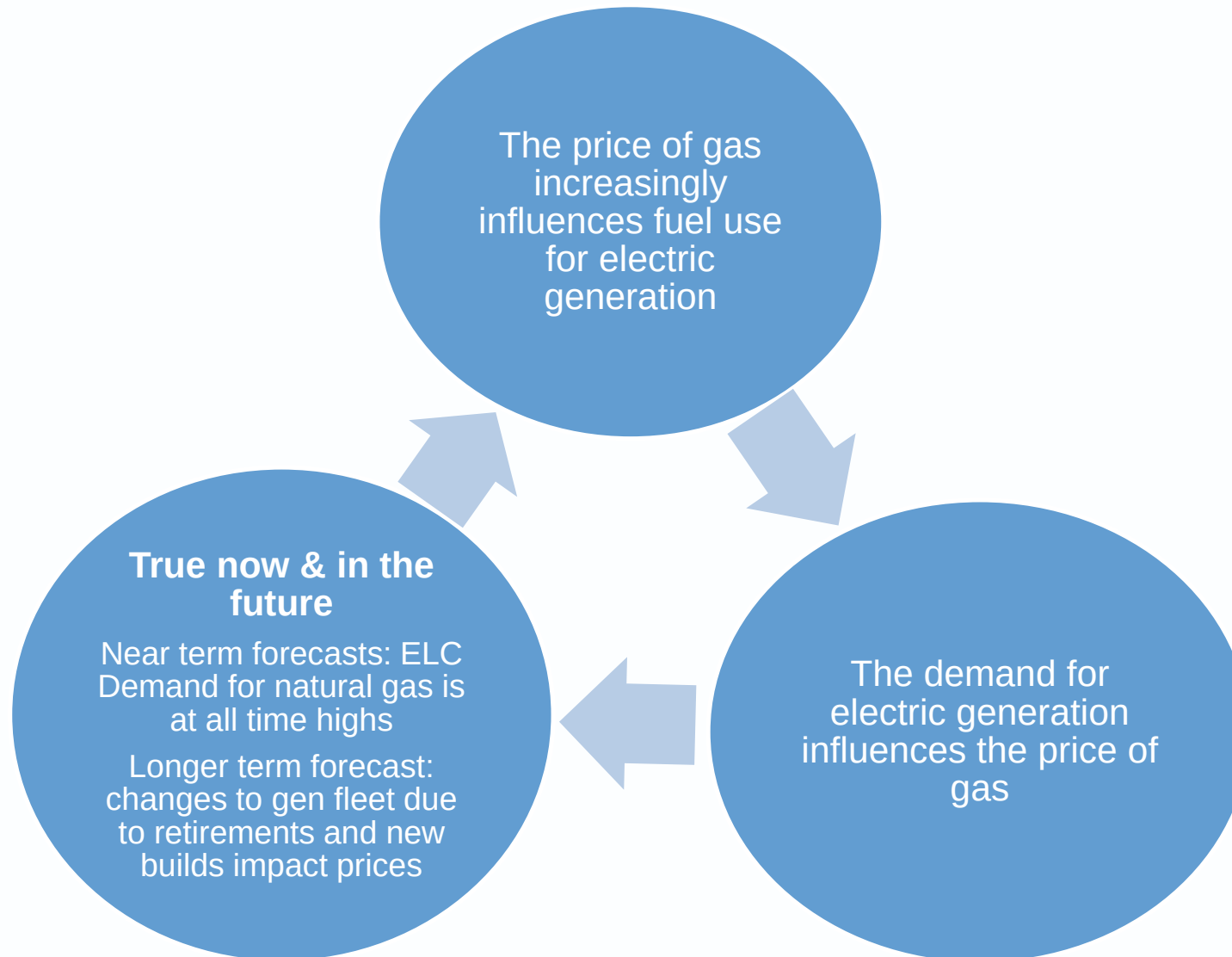
Increasing Share Amongst all Fuels



Units: Share of Market

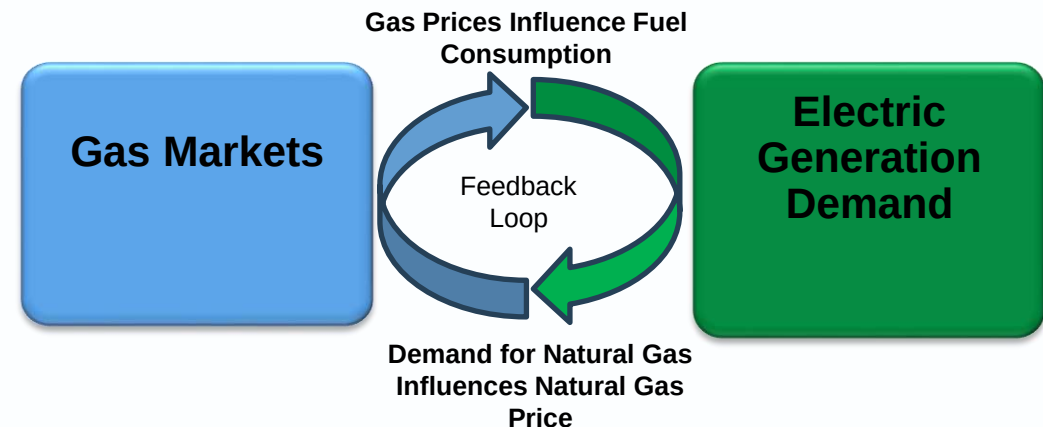
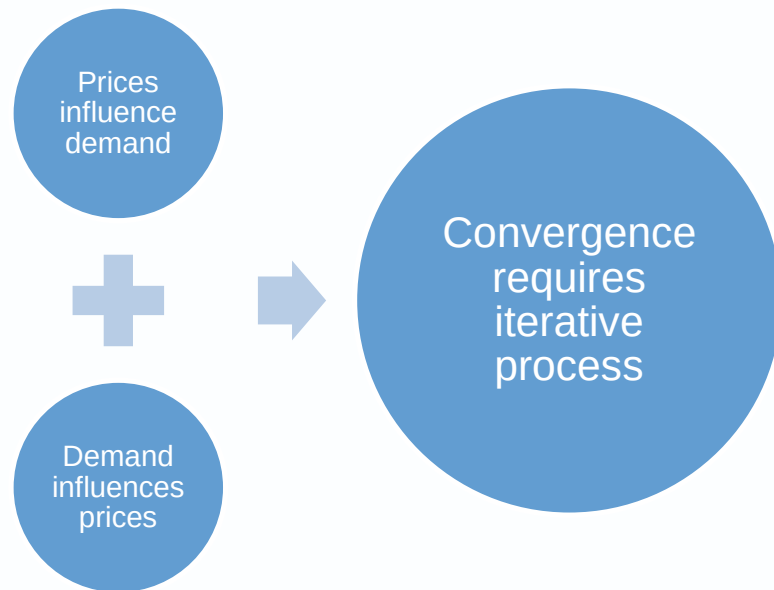
- Growing share of gas demand for electric generation
- Fuel sources for electric demand have been shifting
- The shifts cause an interaction between natural gas and electric generation markets
- As these markets become more intertwined, the need to model these interactions becomes more important

Why is this important



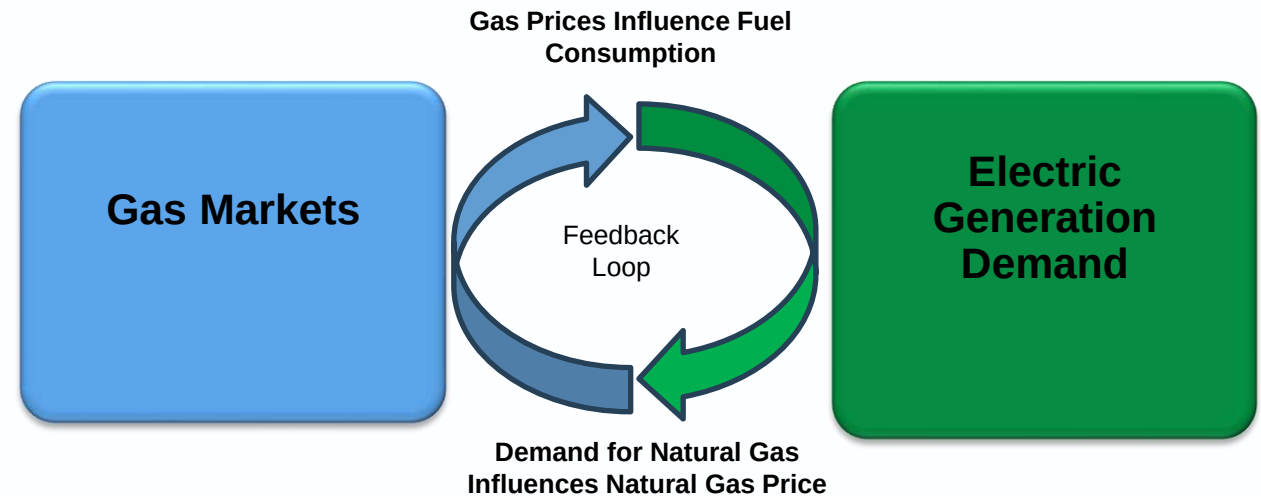
Inter-related markets

- As NG prices influence electric generation and demand from electric generation influences prices, it is important to have a modeling system that can integrate these two interrelated markets
- Many companies use PROMOD, PLEXOS or other software for electricity modeling
 - Natural Gas prices are an input to these models
 - These systems do not have a 'feedback loop' to account for the interrelatedness of these markets





How to Model Interrelated Gas & Power Markets



Modeling Interrelated Markets

- To capture the interrelatedness of Gas and Power Markets, models are typically iterated
- GPCM can be iterated with a variety of power models
- It is generally a complex set-up

Thousands of generators mapped to hundreds of natural gas customers

Tracking demand and price changes

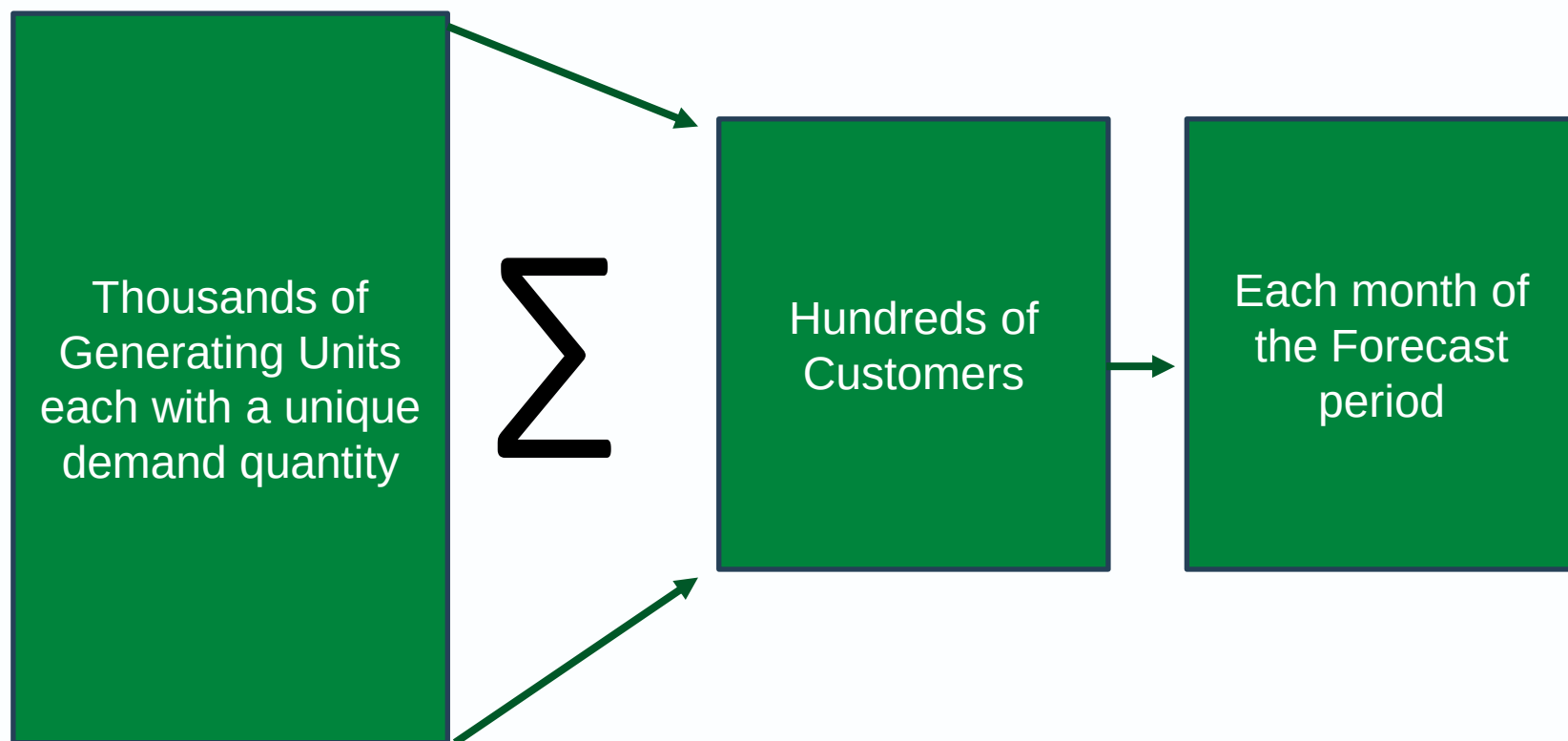
The need for solutions to converge; relatively quickly

Easy system for importing and exporting large data sets between iterations

Need for iteration diagnostics and statistics

Large Data Sets Need to be Aggregated

Inputs need to be aggregated between iterations

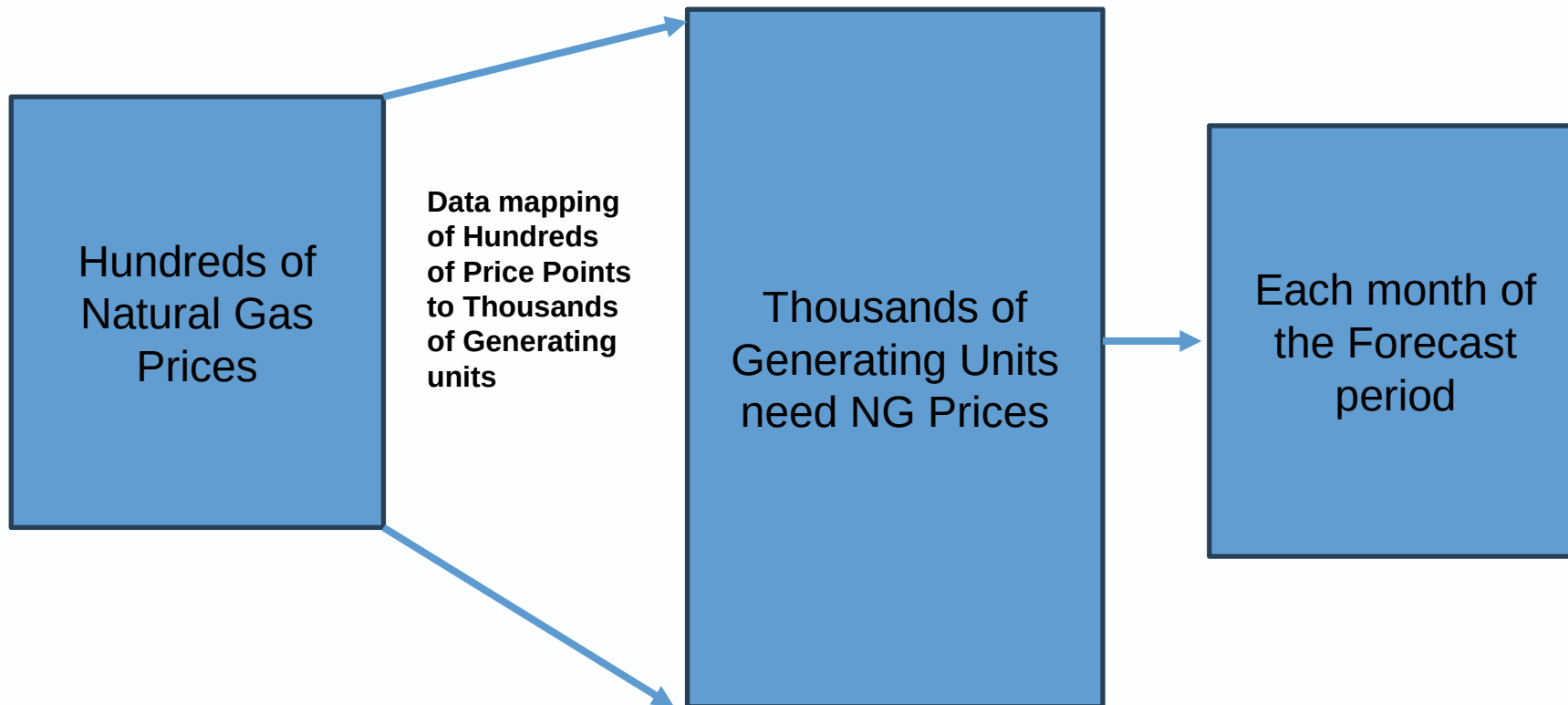


Note: Each time period could have a different set of generating unit records as new units come online and older units retire

- Demand from Thousands of Generating Units needs to be Aggregated to the Customer Level
- This aggregations needs to be computed for each month in the forecast period
 - Example, a 10-year forecast with 3,000 generating units will have data set of around 360,000 records.
 - The records will have to get aggregated monthly by customer to create demand inputs for a gas model.
 - A 30-year forecast would have a starting point of almost a million records

Hundreds of Prices Matched to Thousands of Unit

Inputs need to be matched / assigned between iterations



- Natural Gas Prices at over 100 locations need to be assigned to each generating unit
- This data mapping needs to be computed for each month in the forecast period
 - Example, a 10-year forecast with 100 price points will have data set of around 12,000 records. These price points will have to be mapped to 360,000 generating unit records
 - A 30-year forecast would need to map 36,000 price points to over a million generating unit records

RBAC's PMI for Gas and Power Modeling

Power Model to GPCM Map

Power Model Area Fuel Codes to Market Points New Unmapped Units in Gas Burn Data

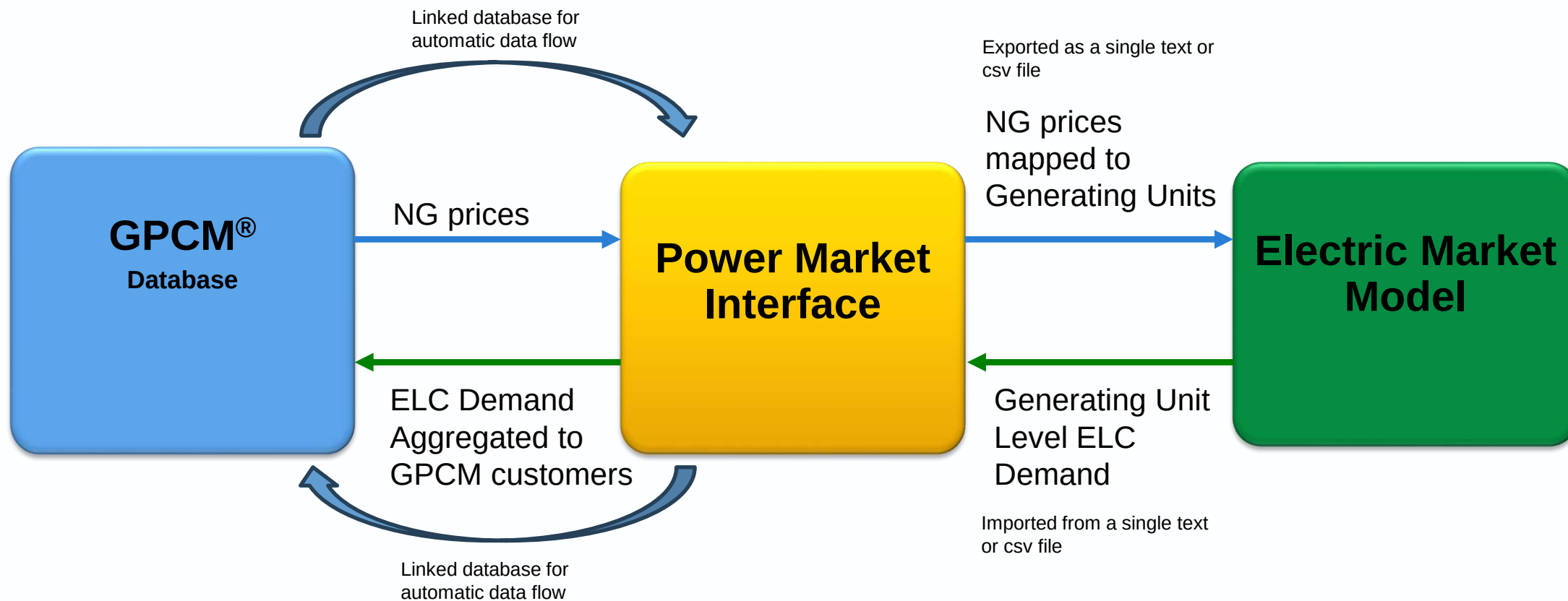
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AB110_2	Weldwood:1	3001			AB	AB-CAN	NG Alberta	20	☐
AB90_2	Rainbow (AB):1	3001			AB	AB-CAN	NG Alberta	30	☐
AB90_3	Rainbow (AB):2	3001			AB	AB-CAN	NG Alberta	40	☐
AB90_4	Rainbow (AB):4	3001			AB	AB-CAN	NG Alberta	45	☐
AL1_1	Barry:1	44			AL	SE	NG Southeast	138	☐
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AL5_1	Barry:A1	44			AL	SE	NG Southeast	539	☐
AL6_1	Barry:A2	44			AL	SE	NG Southeast	532	☐
AL7_1	Gadsden:1	44			AL	SE	NG Southeast	64	☐
AL8_1	Gadsden:2	44			AL	SE	NG Southeast	66	☐
AL9_1	James A Vann Jr:CC1	44			AL	SE	NG Southeast	539	☐
AR1_1	MISO-Ark_CC_2034_1 (H Class)	7			AR	MISO-Ark	NG Louisiana	425	☐
AR2_1	MISO-Ark_CC_2037_1 (H Class)	7			AR	MISO-Ark	NG Louisiana	425	☐
BC240_1	Burrard:1	3003			BC	BC-CAN	NG BC	150	☐
BC241_1	Burrard:3	3003			BC	BC-CAN	NG BC	150	☐
BC242_1	Burrard:4	3003			BC	BC-CAN	NG BC	150	☐
BC243_1	Burrard:5	3003			BC	BC-CAN	NG BC	150	☐
BC244_1	Burrard:6	3003			BC	BC-CAN	NG BC	150	☐
CT1_1	Bridgeport Harbor CC:6	18			CT	NE-CTSW	NG ISO-NE S	530	☐
CT2_1	Burrillville EC:1	22			CT	NE-SEMA	NG ISO-NE S	518	☐
CT3_1	Footprint CC:1	19			CT	NE-EAST	NG ISO-NE S	674	☐
CT4_1	MATEP:1	20			CT	NE-MAB	NG ISO-NE S	63	☐
EAI345_1	Mandalay:1	3007			CA	CA-SCE	NG CAISO - S	215	☐

Record: 1 of 4740 Unfiltered Search

- **Power Model Interface (PMI)**
 - Organizes and maps units, customers and prices
 - Tracks price and demand changes between iterations
 - Helps solutions convergence
 - Handles exchange of large data sets
 - Set of diagnostics and statics for tracking and checking data

How PMI Works

The PMI links to a GPCM database much the same as our user interface
Data between the GPCM database and PMI flows automatically (linked)
Data between PMI and the Electric model are handled through single csv or text files



RBAC's PMI for GPCM

Quick Look at PMI

Form Tools RBAC, Inc.

File Home Create External Data Database Tools Help Form Datasheet Tell me what you want to do

View Paste Copy Cut Format Painter Filter Sort & Filter Selection Advanced Toggle Filter Refresh Save Spelling Find Replace Go To Select Text Formatting

Power Model Interface

GPCM® Power Model Interface™ v. 5.2.1.3

PMIDat DB: C:\RBAC\GPCM\PMI\DATABASES\2024 RBAC User Conf.acddb

GPCM DB: C:\RBAC\GPCM\24Q3\Bases\24Q3base.acddb

Help Diagnostic Queries Link to PMID DB Link to GPCM DB Export PMID DB Import Gasburn Build Dem Case Open GPCM Import Prices Export Prices Rename Gasburn Delete Gasburn Rename Price Test Delete Price Test Compact PMIDat

Power Model to GPCM Map Power Model Area Fuel Codes to Market Points New Unmapped Units in Gas Burn Data

Unit	Unit_Name	Area	Cust Name	Loc Name	State	Utility	Fuel	Cap	Exclude			
AB110_2	Weldwood:1	3001			AB	AB-CAN	NG Alberta	20	☐			
AB90_2	Rainbow (AB):1	3001			AB	AB-CAN	NG Alberta	30	☐			
AB90_3	Rainbow (AB):2	3001			AB	AB-CAN	NG Alberta	40	☐			
AB90_4	Rainbow (AB):4	3001			AB	AB-CAN	NG Alberta	45	☐			
AL1_1	Barry:1	44			AL	SE	NG Southeast	138	☐			
AL2_1	Barry:2	44			AL	SE	NG Southeast	137	☐			
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BC242_1	Burrard:4	3003			BC	BC-CAN	NG BC	150	☐			
BC243_1	Burrard:5	3003			BC	BC-CAN	NG BC	150	☐			
BC244_1	Burrard:6	3003			BC	BC-CAN	NG BC	150	☐			
CT1_1	Bridgeport Harbor CC:6	18			CT	NE-CTSW	NG ISO-NE S	530	☐			
CT2_1	Burrillville EC:1	22			CT	NE-SEMA	NG ISO-NE S	518	☐			
CT3_1	Footprint CC:1	19			CT	NE-EAST	NG ISO-NE S	674	☐			
CT4_1	MATEP:1	20			CT	NE-MAB	NG ISO-NE S	63	☐			
EAI345_1	Mandalay:1	3007			CA	CA-SCE	NG CAISO - S	215	☐			

Record: 14 of 4740 Unfiltered Search

PMI Interface

Form Tools RBAC, Inc.

File Home Create External Data Database Tools Help Form Datasheet Tell me what you want to do

Views Clipboard Sort & Filter Records Find Text Formatting

Power Model Interface

GPCM® Power Model Interface™ v. 5.2.1.3

PMIdat DB: C:\RBAC\GPCM\PMI\DATABASES\2024 RBAC User Conf.accdb

GPCM DB: C:\RBAC\GPCM\24Q3\Bases\24Q3base.accdb

Help Diagnostic Queries Link to PMI DB Link to GPCM DB Export PMI DB Import Gasburn Burns Graph Build Dem Case Open GPCM Import Prices Prices Graph Export Prices Prices Graph Rename Gasburn Delete Gasburn Rename Price Fest Delete Price Fest Compact PMIdat Close PMI

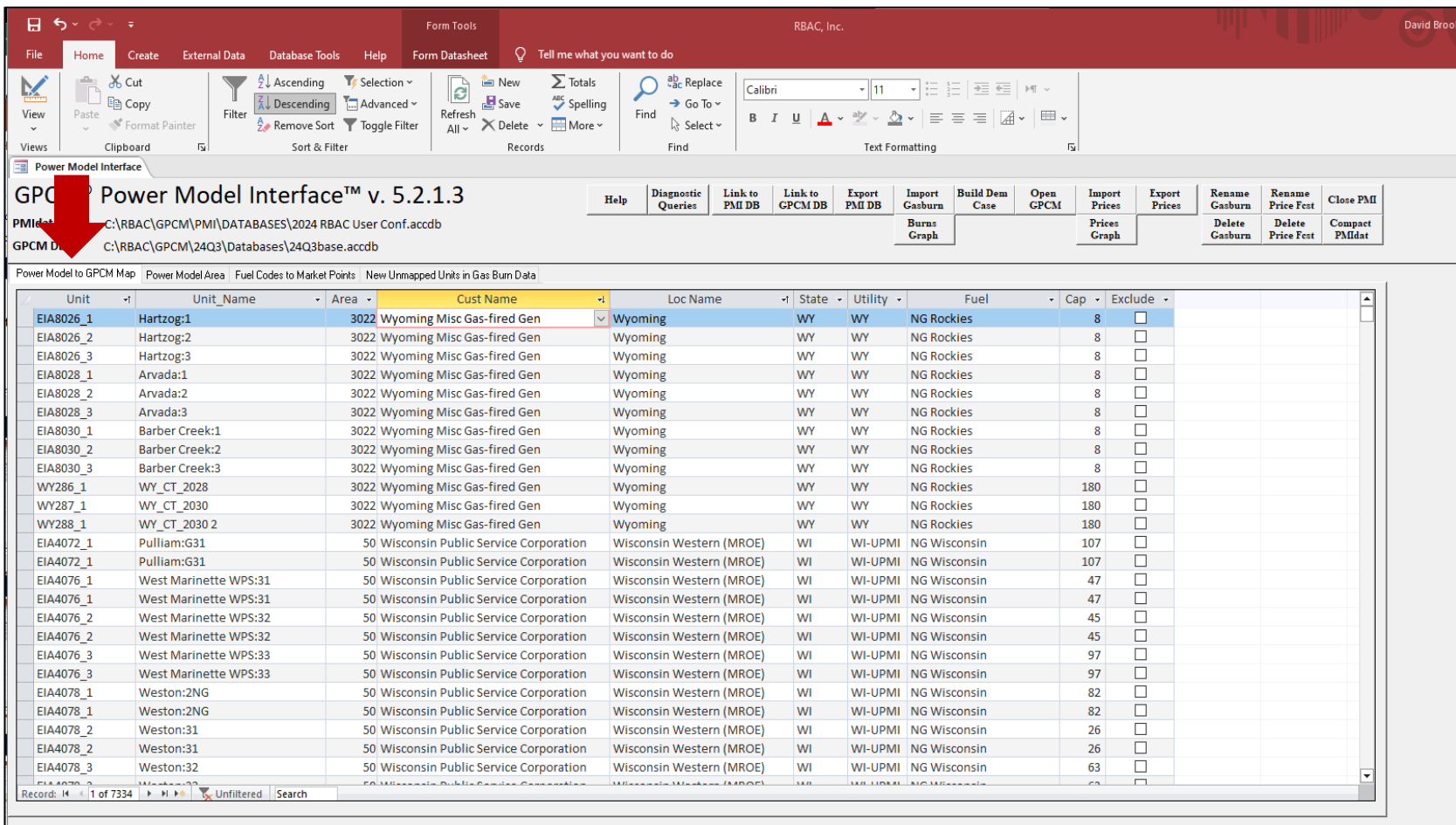
Power Model to GPCM Map Power Model Area Fuel Codes to Market Points New Unmapped Units in Gas Burn Data

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AB90_2	Rainbow (AB):1	3001			AB	AB-CAN	NG Alberta	30	☐
AB90_3	Rainbow (AB):2	3001			AB	AB-CAN	NG Alberta	40	☐
AB90_4	Rainbow (AB):4	3001			AB	AB-CAN	NG Alberta	45	☐
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CT3_1	Footprint CC:1	19			CT	NE-EAST	NG ISO-NE S	674	☐
CT4_1	MATEP:1	20			CT	NE-MAB	NG ISO-NE S	63	☐
EAI345_1	Mandalay:1	3007			CA	CA-SCE	NG CAISO - S	215	☐

Record: 1 of 4740 Unfiltered Search

1. Import Databases
2. Import Gasburns generated by power model
3. Review Gasburns
4. Build Demand case for GPCM
5. Import Prices from GPCM
6. Review prices
7. Export prices to import into power model

Mapping Units to GPCM



The screenshot shows the Power Model Interface v. 5.2.1.3 application. The interface includes a menu bar (File, Home, Create, External Data, Database Tools, Help, Form Datasheet), a ribbon with various tools (Views, Clipboard, Sort & Filter, Records, Find, Text Formatting), and a main data table. A red arrow points to the 'Unit' column header in the table.

Unit	Unit_Name	Area	Cust Name	Loc Name	State	Utility	Fuel	Cap	Exclude
EIA8026_1	Hartzog:1	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8026_2	Hartzog:2	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8026_3	Hartzog:3	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8028_1	Arvada:1	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8028_2	Arvada:2	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8028_3	Arvada:3	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8030_1	Barber Creek:1	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8030_2	Barber Creek:2	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
EIA8030_3	Barber Creek:3	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	8	☐
WY286_1	WY_CT_2028	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	180	☐
WY287_1	WY_CT_2030	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	180	☐
WY288_1	WY_CT_2030 2	3022	Wyoming Misc Gas-fired Gen	Wyoming	WY	WY	NG Rockies	180	☐
EIA4072_1	Pulliam:G31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	107	☐
EIA4072_1	Pulliam:G31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	107	☐
EIA4076_1	West Marinette WPS:31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	47	☐
EIA4076_1	West Marinette WPS:31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	47	☐
EIA4076_2	West Marinette WPS:32	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	45	☐
EIA4076_2	West Marinette WPS:32	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	45	☐
EIA4076_3	West Marinette WPS:33	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	97	☐
EIA4076_3	West Marinette WPS:33	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	97	☐
EIA4078_1	Weston:2NG	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	82	☐
EIA4078_1	Weston:2NG	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	82	☐
EIA4078_2	Weston:31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	26	☐
EIA4078_2	Weston:31	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	26	☐
EIA4078_3	Weston:32	50	Wisconsin Public Service Corporation	Wisconsin Western (MROE)	WI	WI-UPMI	NG Wisconsin	63	☐

Record: 14 of 7334 | Unfiltered | Search

Map Power units used in the power model to GPCM Customer and GPCM Location.

Further research on how to map to GPCM may occur when there are units not reported to EIA OR naming conventions are different.

Define Areas used by Power Model

GPCM® Power Model Interface™ v. 5.2.1.3

PMIdat DB: C:\RBAC\GPCM\PMIDAT\DATABASES\2024 RBAC User Conf.accdb
 GPCM DB: C:\RBAC\GPCM\24Q3\DATABASES\24Q3base.accdb

Power Model to GPCM Map | Power Model Area | Fuel Codes to Market Points | New Unmapped Units in Gas Burn Data

Area	Area Name	Shortname	Interconnect	Country	Exclude
1	AECI	AECI	East	USA	☐
2	Dakotas	Dakotas	East	USA	☐
3	Florida	Florida	East	USA	☐
4	Kentucky	Kentucky	East	USA	☐
5	Manitoba	Manitoba	East	CAN	☐
6	MAR-CAN	MAR-CAN	East	CAN	☐
7	MISO-Ark	MISO-Ark	East	USA	☐
8	MISO-Gul	MISO-Gul	East	USA	☐
9	MISO-IA	MISO-IA	East	USA	☐
10	MISO-IL	MISO-IL	East	USA	☐
11	MISO-IN	MISO-IN	East	USA	☐
12	MISO-MI	MISO-MI	East	USA	☐
13	MISO-MN	MISO-MN	East	USA	☐
14	MISO-MO	MISO-MO	East	USA	☐
15	MISO-MS	MISO-MS	East	USA	☐
16	MISO-ND	MISO-ND	East	USA	☐
17	NC-SC	NC-SC	East	USA	☐
18	NE-CTSW	NE-CTSW	East	USA	☐
19	NE-EAST	NE-EAST	East	USA	☐
20	NE-MAB	NE-MAB	East	USA	☐
21	NE-ME	NE-ME	East	USA	☐
22	NE-SEMA	NE-SEMA	East	USA	☐
23	NE-WEST	NE-WEST	East	USA	☐
24	NY-AB	NY-AB	East	USA	☐
25	NY-CDE	NY-CDE	East	USA	☐
26	NY-F	NY-F	East	USA	☐

Record: 1 of 76 | No Filter | Search

- Each unit and customer is mapped to Electric model areas
- Data aggregations can be useful for comparing and checking data

Map Fuel codes to GPCM Market Points

The screenshot shows the GPCM Power Model Interface v. 5.2.1.3. The main window displays a table with the following columns: Fuel_Code, Fuel_Name, and Market_Points and Zones. The table lists various fuel codes and their corresponding market points or zones.

Fuel_Code	Fuel_Name	Market_Points and Zones
NG ERCOT - W		Waha
NG NM		Waha
NG VACAR		Transco Z5
NG NY West		Niagara
NG Louisiana		Henry Hub
NG AECI		ANR SW
NG KSMO		ANR SW
NG Missouri		ANR SW
NG Oklahoma		ANR SW
NG West SPP		ANR SW
NG Alberta		TCPL Alberta, AECO-C
NG Arkansas		
NG AZ		
NG BC		Westcoast, station 2
NG CAISO - N		
NG CAISO - S		
NG Central Valley		
NG Colorado		
NG COMED		
NG Dakotas		
NG ERCOT - H		
NG ERCOT - N		
NG ERCOT - S		
NG Florida		Florida city-gates
NG Idaho		
NG Illinois		

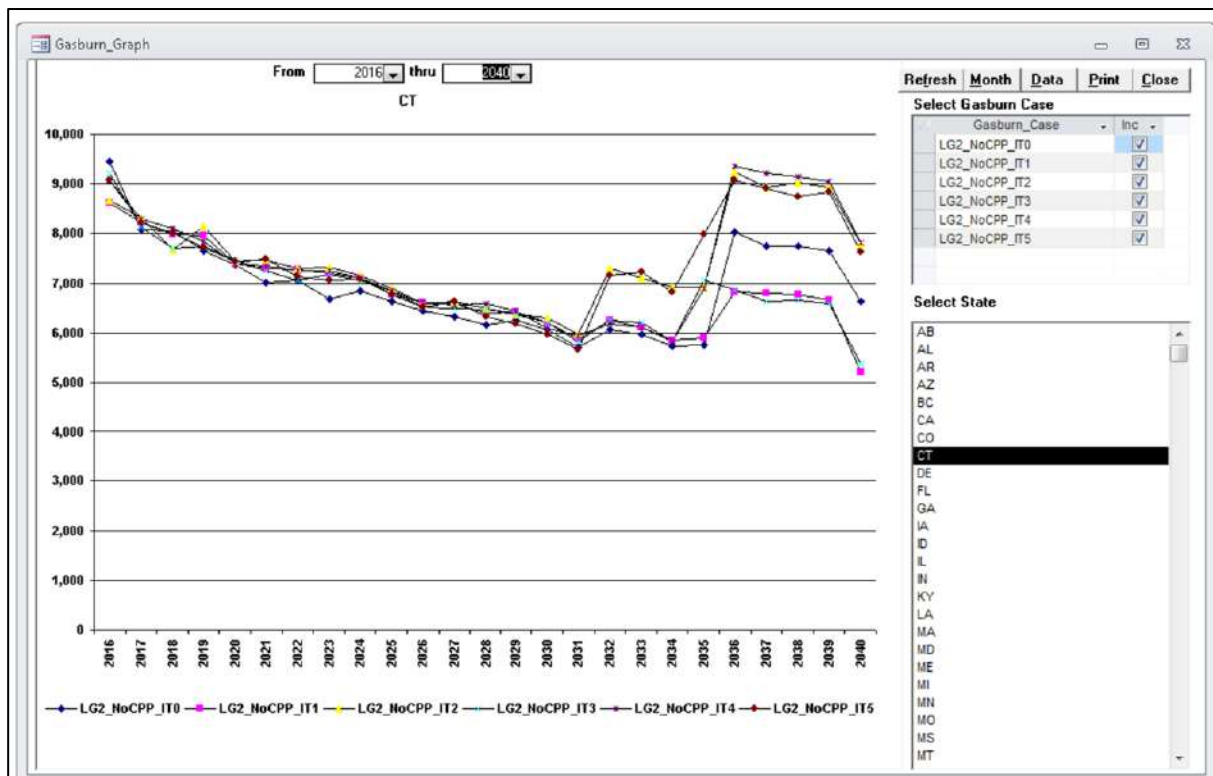
Fuel codes can also be mapped to a pipe zone rather than a Market point

Typical Iteration Run

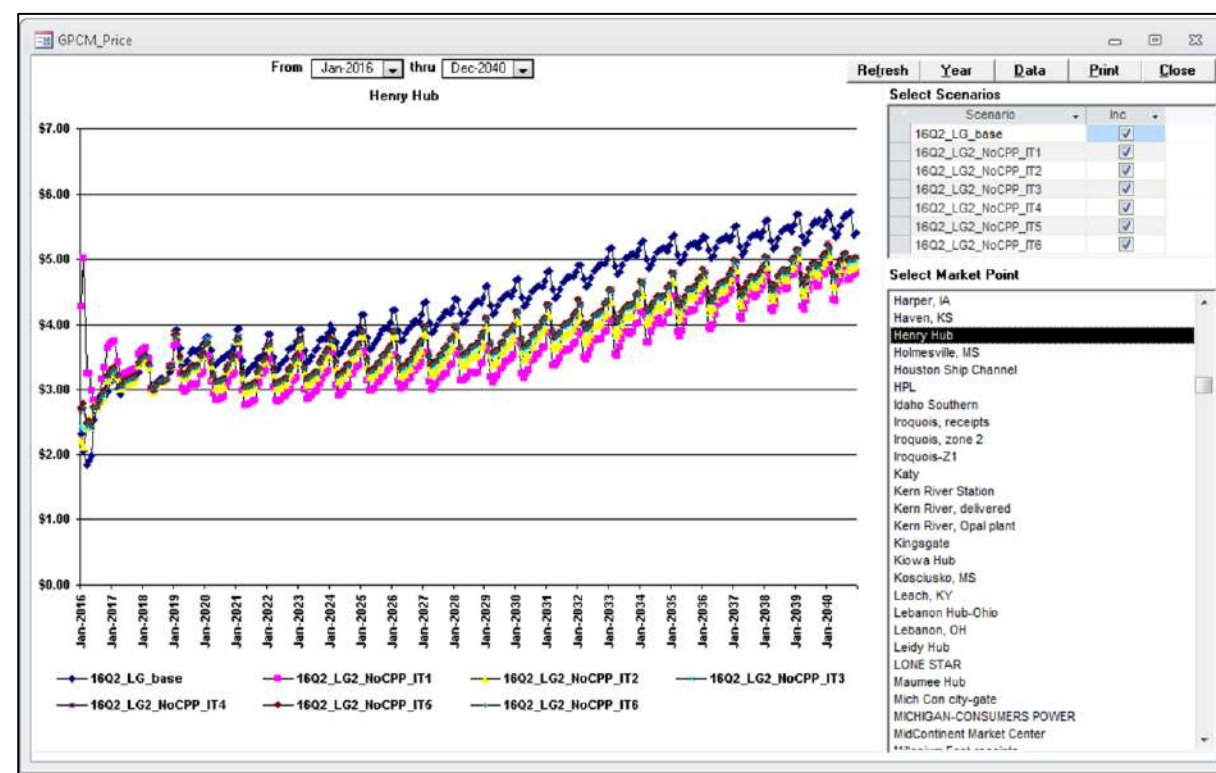
1. Import Gasburns generated by the electric model
2. Review Gasburns inside PMI
 - Electric model may need to be reran if anything looks out of the ordinary
 - Or Gasburn file needs to just be corrected
3. Once Gasburns look good, build demand case for GPCM
4. Inside GPCM select the new demand case and run the model
5. After GPCM runs reopen PMI and import the prices
6. Review prices in PMI, if everything looks good, export prices for electric model
7. Run the electric model with the new Prices
8. Repeat steps 1-7 until you have convergence.

Systems for Tracking Changes

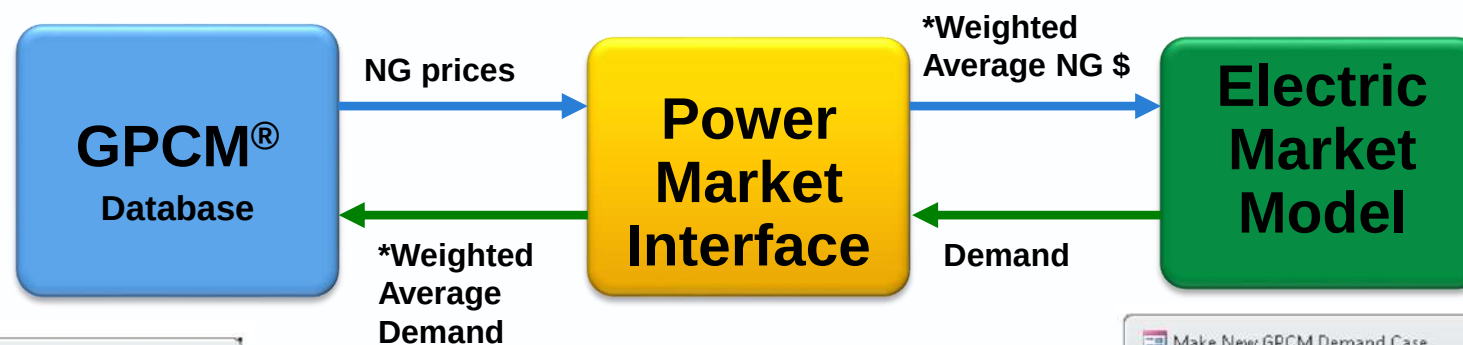
Demand records for each iteration by state



Price records for each iteration by hub



Solution Convergence



Export GPCM Prices

Export GPCM Prices

Exp Wt Factor: 0.618

Scenario	Weight
16Q2_LG_base	0.31%
16Q2_LG2_NoCPP_IT1	0.50%
16Q2_LG2_NoCPP_IT2	1.32%
16Q2_LG2_NoCPP_IT3	3.44%
16Q2_LG2_NoCPP_IT4	9.02%
16Q2_LG2_NoCPP_IT5	23.61%
16Q2_LG2_NoCPP_IT6	61.80%

GPCM Price Scenario Name: Thru_16Q2_LG2_NoCPP_IT6

Tot Weight: 100.00%

Export Prices Cancel

*RBAC's PMI uses a weighted average formula that has been proven to promote convergence between gas and power models

Make New GPCM Demand Case

New Demand Case: 16Q2_CPP_IT6

Based On: 16Q2base

Max Price: 20.00

Min Price: 1.00

Spread (+/-): 1.00%

Elasticity (calc): 0.007

BTU / CF: 1.028

Exp Wt Factor: 0.6180

Country	Include
CAN	☒
MEX	☐
USA	☒

Power_Model_Case Weights

Interconnect	Power_Model_Case	Weight
Eastern	CPP_IT0	0.31%
Eastern	CPP_IT1	0.50%
Eastern	CPP_IT2	1.32%
Eastern	CPP_IT3	3.44%
EASTERN	CPP_IT4	9.02%
EASTERN	CPP_IT5	23.61%
Eastern	CPP_IT6	61.80%
ERCOT	CPP_IT0	0.31%
ERCOT	CPP_IT1	0.50%

Make New Case Cancel



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RBAC leads the market in global and regional gas and LNG market simulation and predictive analytics in support of corporate investment and M&A strategy, ESG, risk analysis, planning, and commodity trading. Our products and expertise help companies go beyond the narratives and hype to identify the opportunities and define the risks inherent in the uncertainties of energy transition using reality and fact-based fundamentals and analysis.

We continuously enhance our market simulation systems with the latest software and computer technology while applying the best of mathematical economics to assist our clients achieve their goals. This is especially needed as we see fundamental shifts taking place in the energy industry to achieve energy transition goals and meet increasingly demanding requirements of ESG. We provide regularly scheduled updates of our simulation systems and databases to keep our clients up-to-date with the most current market information. We enhance the functionality of our systems to enable our customers to simulate the effect of new regulations or industry requirements.

Our aim is to continue to lead the market in best practices which raise the standard of market simulation, enabling rapid and flexible scenario generation, sensitivity analysis, risk-assessment and forecasting, giving clients the edge in the rapidly changing energy market.

Those using RBAC's products and services include energy industry firms and consultants, as well as government agencies involved with energy, transportation, and the environment.

RBAC's principal products include:

- **GPCM® Market Simulator for North American Gas and LNG™** focused on the North American gas & LNG markets. GPCM is the industry standard market simulator for North American gas.
- **G2M2® Market Simulator for Global Gas and LNG™** for simulating increasingly integrated gas and LNG markets worldwide.
- **Gas4Power®** for integrating gas and power market fundamentals to produce credible forecasts for both.
- **NGL-NA®** Market Simulator for North American Natural Gas Liquids

With RBAC's advanced simulation systems, licensees can create and run scenarios involving bio-methane (Renewable Natural Gas – RNG) mixed with natural gas and to assess the implications of carbon taxes and markets on supply, demand, and prices. Future enhancements will include the ability to simulate the advent of a future hydrogen market with both pure hydrogen pipelines as well as mixtures with methane. The Energy Analyst of today and the future needs these kinds of tools to conduct realistic assessments and help develop realistic strategies and plans to achieve the goals of the energy transition.

Dr. Robert Brooks founded RBAC in 1987 based on experience developing several well-respected predictive models for government and industry. He designed the first gas transportation model while getting his PhD at MIT and has led the industry ever since.

RBAC's staff includes industry-trained experts in natural gas supply and demand, transportation, storage, marketing, and trading. Our team applies its world-class expertise in mathematical modeling, statistical analysis, mathematical algorithm development, software engineering, and database design to current and future challenges, risks and opportunities in energy.

To find out more information about **GPCM** scan:



To schedule a meeting with RBAC email: contact@rbac.com