Optimal Construction and Operation of the GCC Regional Natural Gas and Electricity Production and Transmission Systems

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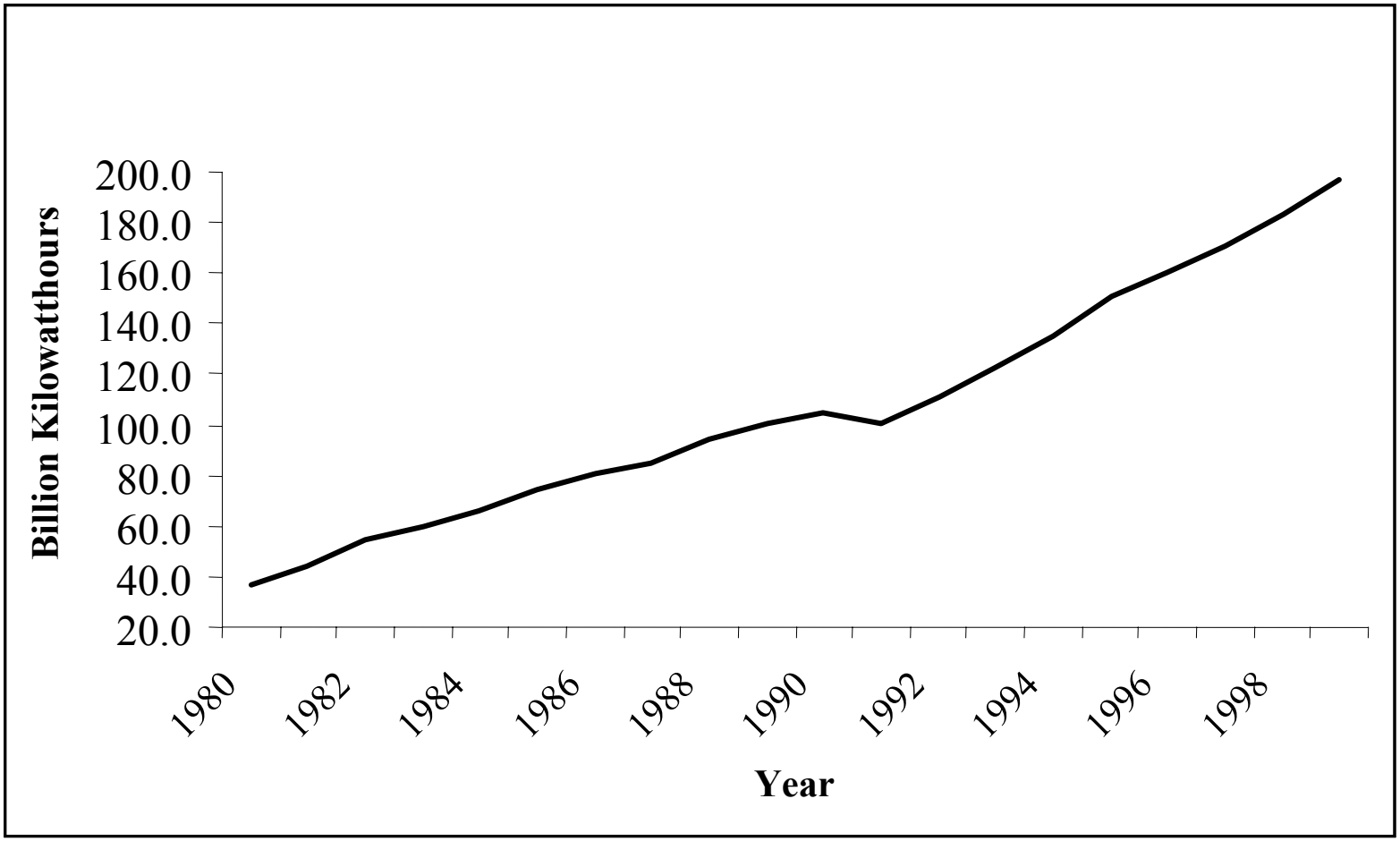
Why Model Natural Gas Systems?

1. To quantity benefits
2. Provide decision support to policy makers
3. Determine least cost or maximum profit
4. Prioritize new construction projects
5. Determine most economically or operationally the most efficient system
6. Avoid weak or unreasonable investments

Why Propose GCC Gas Modeling?

- Major natural gas projects in the GCC region
- Provide analytical long-term planning tools
- Establish gas planning teams within the region
- Integrate a regional gas model with a regional electricity model
- Collaborative planning initiatives with Purdue
- Economic analysis of a regional system beyond the GCC

57% Of The GCC Electricity Generation Uses Natural Gas.

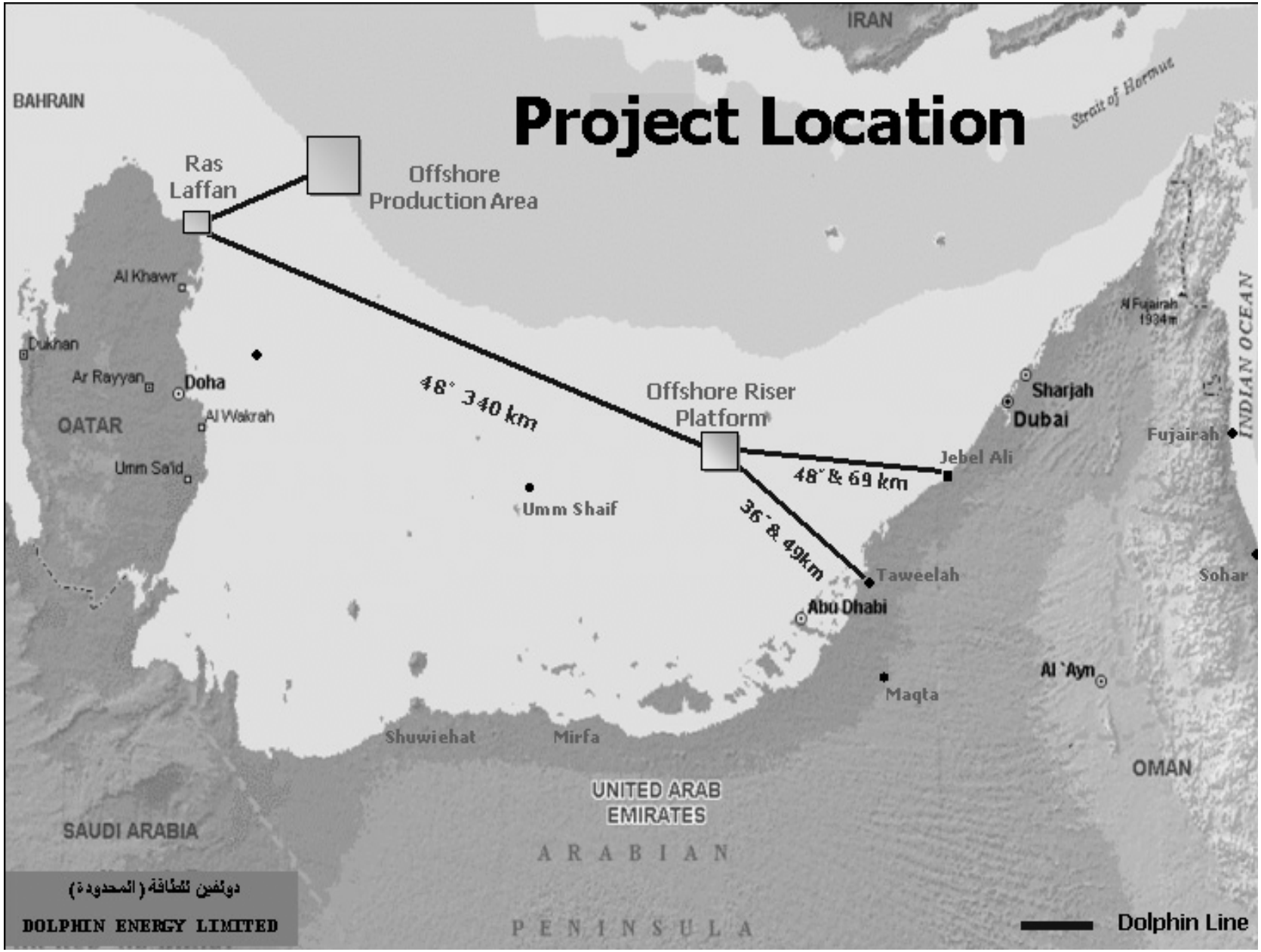


The Total Net Electricity Consumption in the GCC, 1980-1999

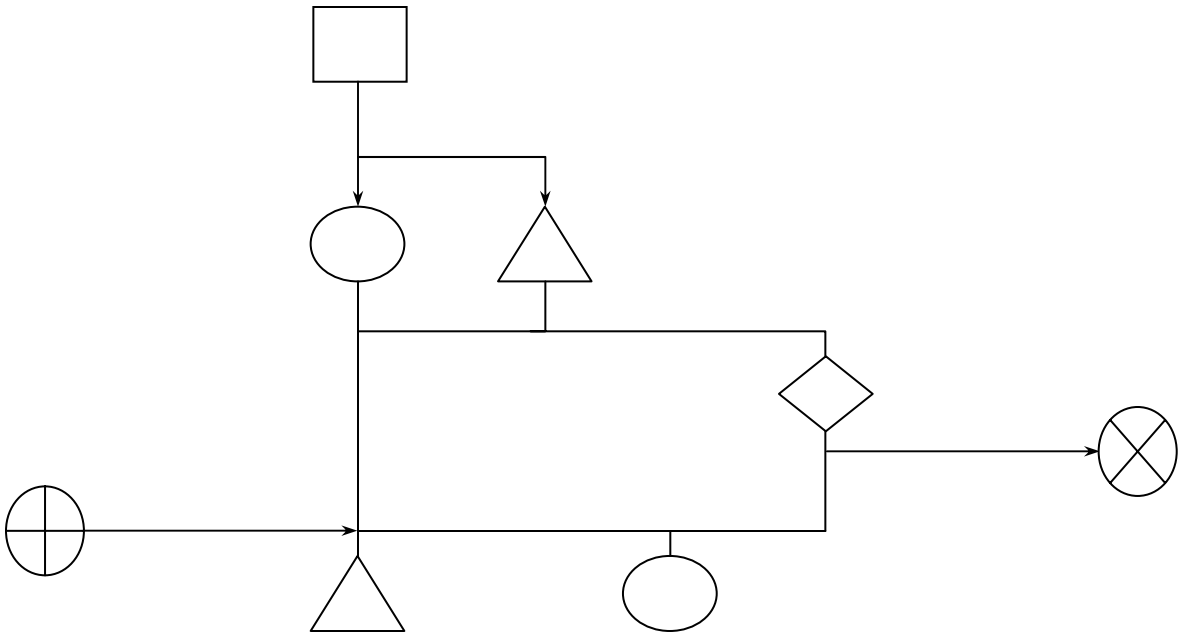
Gulf Natural Gas Reserves

In the GCC, January 1, 2000

	Natural Gas (Trillion Cubic Feet)
Bahrain	4
Kuwait	55
Oman	29
Qatar	347
Saudi Arabia	206
UAE	211
Total	**852**

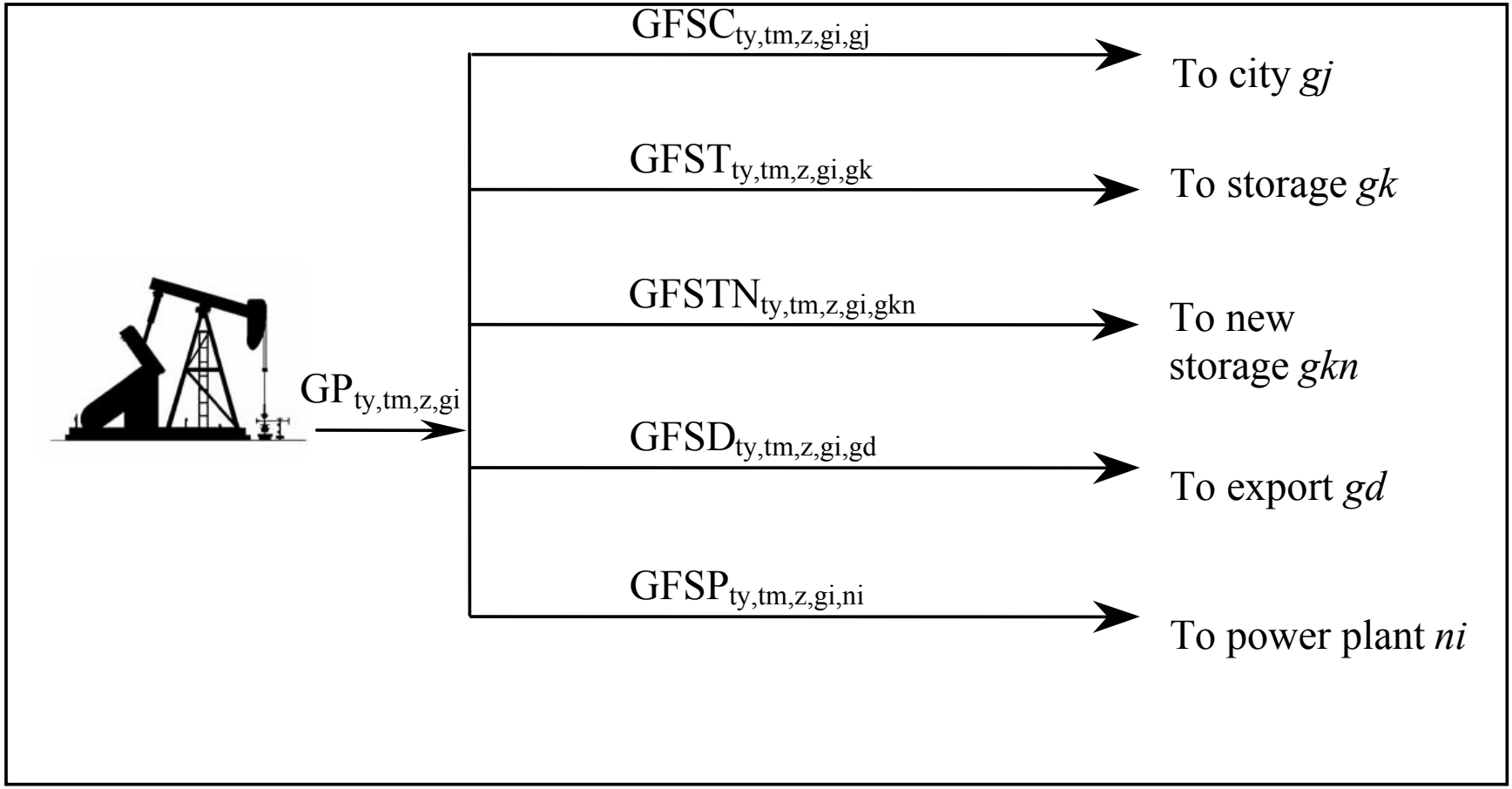

Project Location
IRAN
BAHRAIN
Strait of Hormuz
Ras Laffan
Offshore Production Area
Al Khawr
Dukhan
Ar Rayyan
Doha
Al Wakrah
QATAR
Umm Sa'id
48" 340 km
Offshore Riser Platform
Umm Shaif
48" & 69 km
36" & 49km
Jebel Ali
Sharjah
Dubai
Al Fujairah 1934m
Fujairah
INDIAN OCEAN
Taweelah
Abu Dhabi
Sohar
Al 'Ayn
Maqta
Shuwiehat
Mirfa
OMAN
UNITED ARAB EMIRATES
SAUDI ARABIA
A R A B I A N
P E N I N S U L A
دولفين للطاقة (المحدودة)
DOLPHIN ENERGY LIMITED
Dolphin Line

Topology of the gas model



Key: Square = Gas Source, Circle = City, Triangle = Power Station
Diamond = Storage Site, Links = Pipelines,
Directed Links = Uni-directional pipeline, Undirected Links = Bi-directional pipeline

Flow from a Gas Source



Flow of gas out of a gas source is balanced using the following constraint

$$GP_{ty,tm,z,gi} = \sum_{gj} GFSC_{ty,tm,z,gi,gj} + \sum_{gk} GFST_{ty,tm,z,gi,gk} + \sum_{gd} GFSD_{ty,tm,z,gi,gd}$$

$$+ \sum_{ni} GFSP_{ty,tm,z,gi,ni} + \sum_{gkn} GFSTN_{ty,tm,z,gi,gkn}, \ \forall \text{ ty, tm, z, gi.}$$

The gas production capacity constraint is given by:

$GP_{ty,tm,z,gi} \leq GPMAX_{z,gi}$, $\forall$ ty, tm, z, gi.

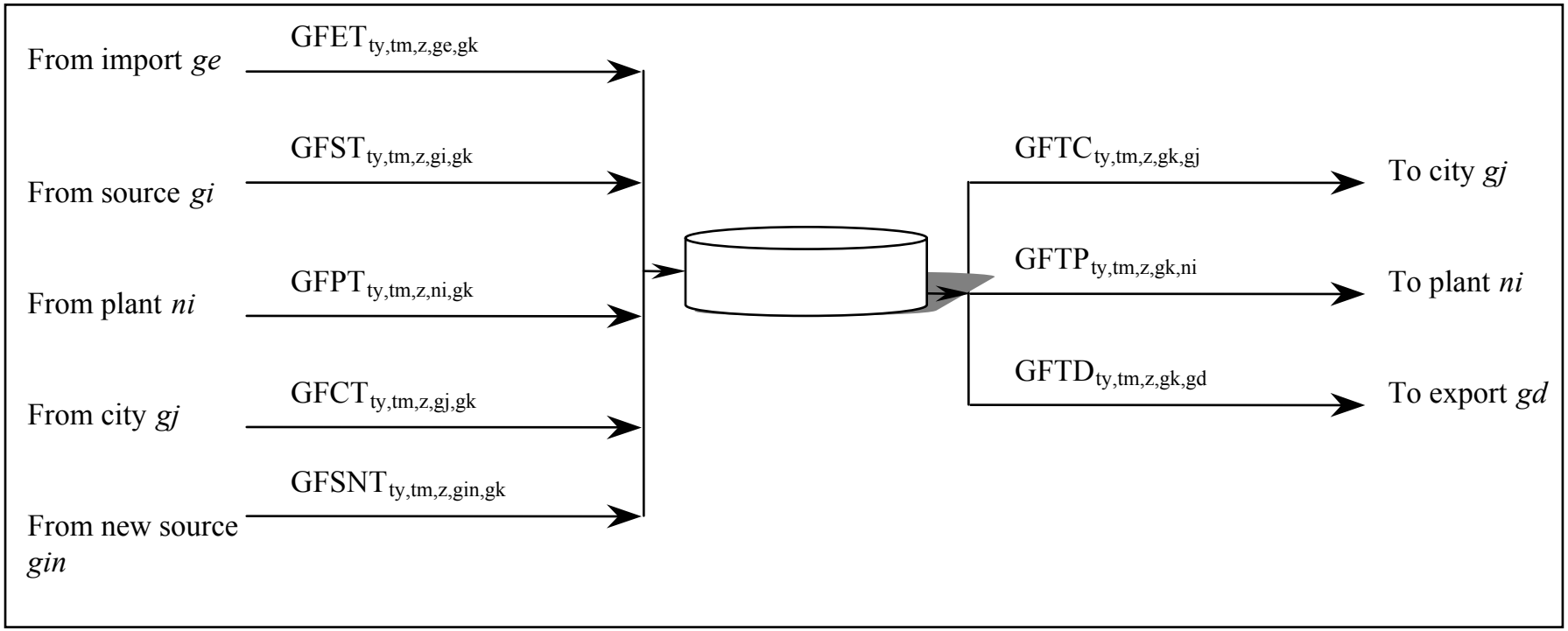
Like the existing gas sources, new gas sources have balance and capacity requirements. The gas flow from a new gas source is balanced by:

$$GPN_{ty,tm,z,gin} = \sum_{gj} GFSNC_{ty,tm,z,gin,gj} + \sum_{gk} GFSNT_{ty,tm,z,gin,gk} + \sum_{gd} GFSND_{ty,tm,z,gin,gd}$$
$$+ \sum_{ni} GFSNP_{ty,tm,z,gin,ni} + \sum_{gkn} GFSNTN_{ty,tm,z,gin,gkn}, \ \forall \text{ ty, tm, z, gin.}$$

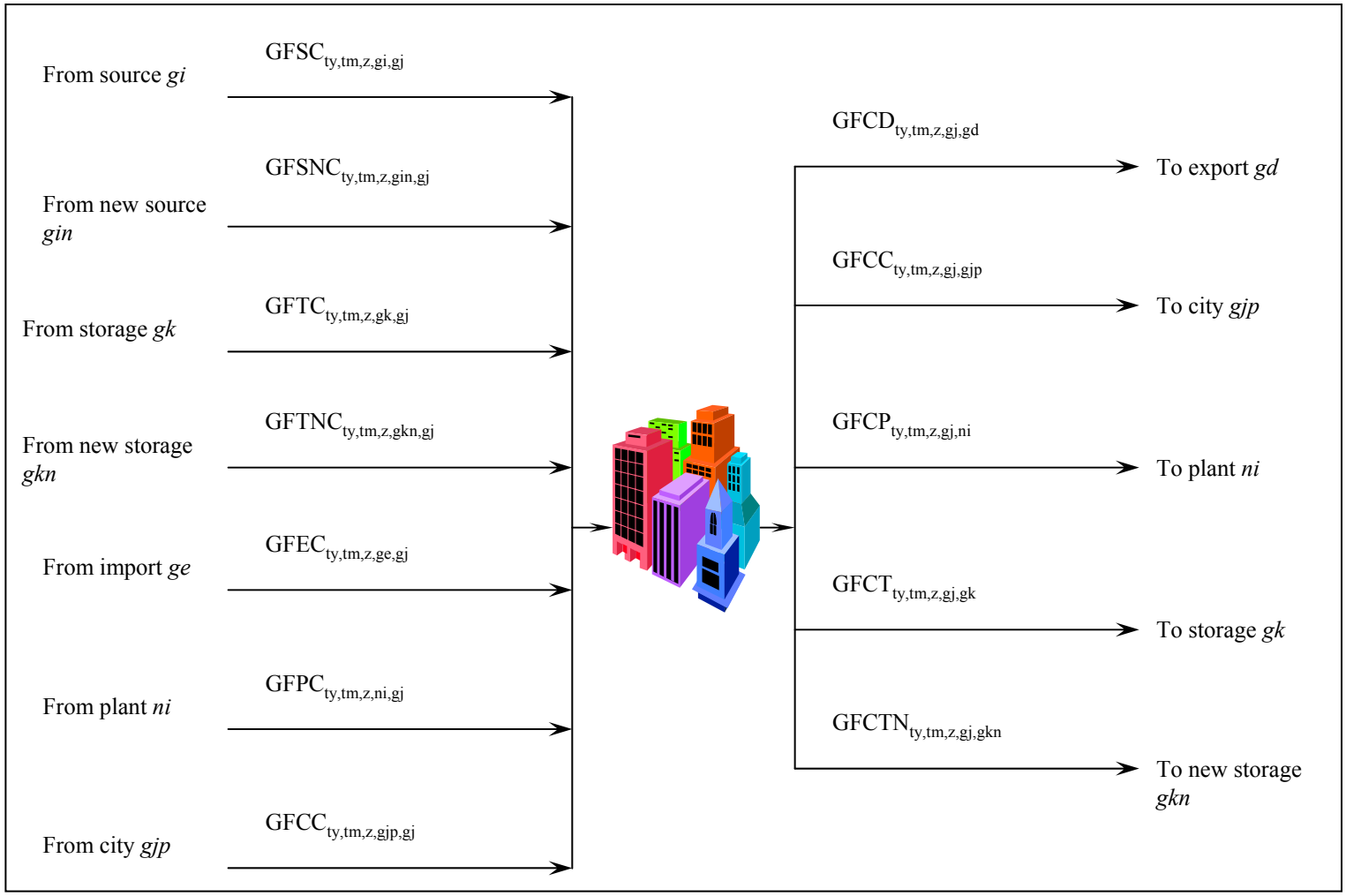
The gas production capacity constraint for a new gas source is given by:

$$GPN_{ty,tm,z,gin} \leq GPMAXN_{z,gin} \cdot \sum_{\tau=1}^{ty} GSNINV_{\tau,z,gin}, \ \forall \text{ ty, tm, z, gin}$$

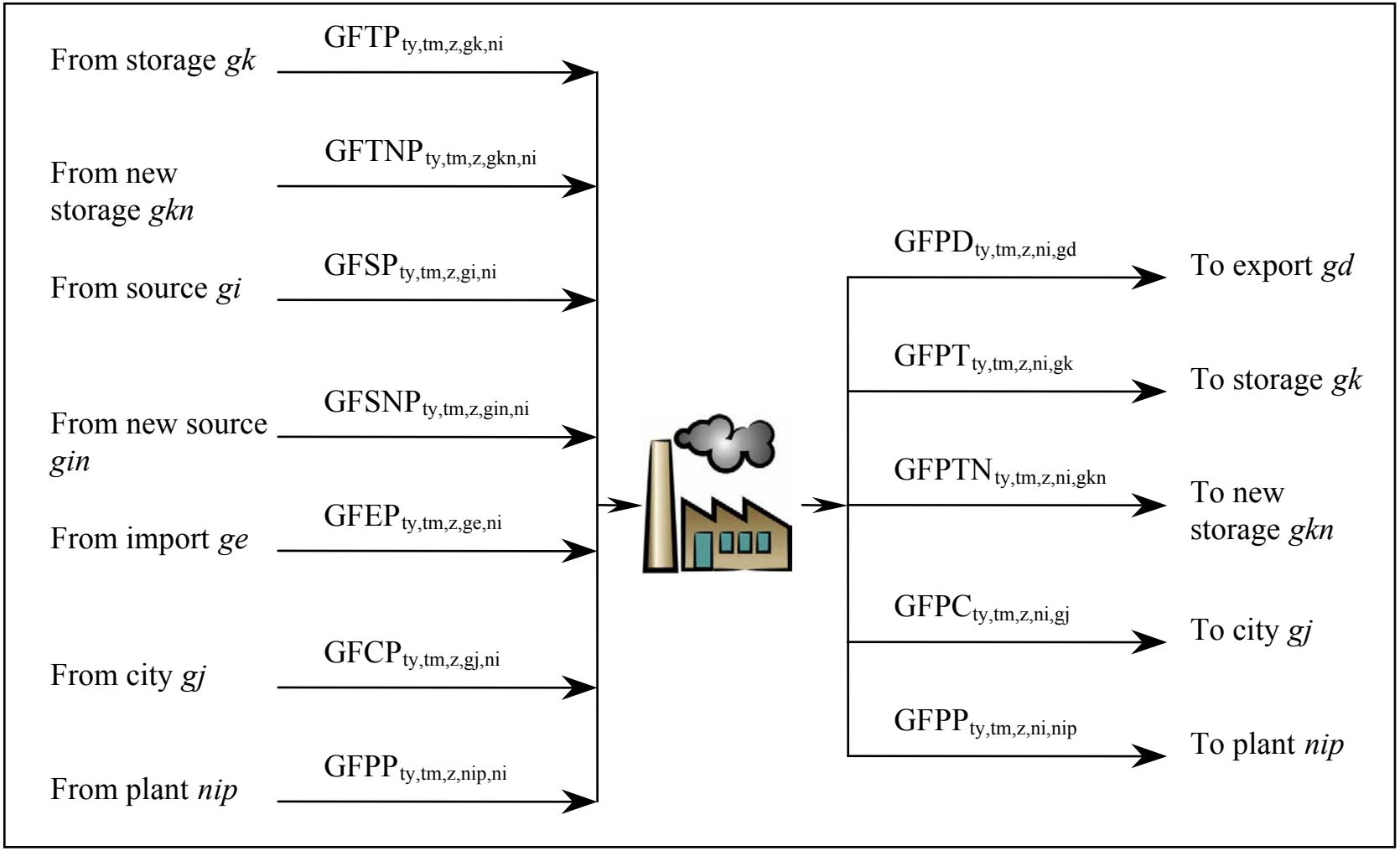
Gas Storage Tank Injection and Withdrawal



Pipelines Entering & Leaving A City.



Gas Flow Entering and Leaving A Power Station



Next Steps

1. Interface gas model with Purdue long-term electricity regional model
2. GCC ~ Middle East data collection
3. Demonstrate benefits of greater regional integration
4. Establish collaborative project within region