Optimizing linepack usage and intraday operations of a gas transmission network, a new approach on GRTgaz network

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Contents

- The complexity of operating a natural gas transmission network

- Building HELP: an hourly GPS for the transmission network

- Benefits in operations
Balancing rules:

- Designed to enhance fluidity for shippers, easy to use
every shipper has to balance input and outputs in balancing zones.

Diagram:

- Network
- Total entries
- Total exits

Graphs showing flow over time.
Balancing rules:
For TSOs: the network is never balanced
TSOs operate a physical network, not a contractual one! Complexity of operating a physical network

- Constraints on pressure (safety / security / contracts)
- Maintenance issues
- Hazards & differences between forecasts and real life!
- Large number of options in a meshed network

**Example of GRTgaz**

- 32 000+ km / 20 000+ miles of pipes
- 6 supply nodes (gas from Norway, Algeria, Russia, …)
- 14 storage facilities
- 36 interconnection (28 compression) stations
- Pressures 40-90bar
- Meshed structure
Optimization: a good tradeoff between Safety, Security & OPEXs

- Safety & Security: constraints
- OPEX: 2 parts: Compression & Flexibility sourcing

Solution developed: two tools communicating

\[ \text{MinOPEX :}
\text{Optimization of compressions costs on daily scenario (steady state)} \]

- Dimensioning compression usage
- Large combination of flow patterns / compressions scheme studied

HELP: Optimization of linepack usage & flexibility sourcing on hourly basis (transient)

- Optimized hourly schedule
- Compression configuration is an input
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HELP : an hourly GPS for TSOs

« Driving hourly the network from here to a target in 24h »

defining « here » and « destination »

Current state: reconstructed in real time from sensors

GRTgaz & CRIGEN : developed accurate reconstruction from 1500+ pressure sensors

Targeted state: linepack target for each pipe

Preparing the network for tomorrow
HELP : an hourly GPS for TSOs

- Driving following an optimized trajectory

- « Driving indications » : for each hour
  - Flows at each end of pipes in the network
  - Flows at storage facilities
  - Flows at LNG terminals

- Linepack trajectories for pipes and large areas around major cities

HELP finds a « way » a « good » way
Finding a way / Finding a good way

A way : respecting the physical & operational constraints
  — Pressures at points always within bounds all day long
  — Contracts with storage facilities / LNG …
  — Security margins to cover temporary failures

⇒ Complex constraints (non linear/non convex Fluid Mechanics equations)

A good way : multicriteria : minimizing costs
  — Contracts with storage facilities / LNG …
  — Distance to target
  — Reasonable solutions : eg smooth changing flows

⇒ There is not one absolute optimal because of multicriteria, it’s a trade off
Describing the “ways”/ feasible set: modeling the network

- **Meshes**: areas with consumptions & interconnections stations. Linepack reservoirs.

- **Pipelines**: Flowing gas from a mesh to the other.

A trajectory = hourly flows at each end of pipes + storages + LNG
Pipeline: the feasible set, steady state computations

Pressure constraints on a pipe:
For a given transmitted flow $Q$: steady state pressure drop profile

What are the limits on linepack to ensure feasibility?

$P(x)$

Max pressure of pipe

Minimal pressures

Q $\rightarrow$ X
Pipeline: the feasible set, steady state computations

For Q varying: all the steady state feasible set
Real life is transient but “close to steady state”

Compute a relevant flow $Q : pressure$ approximated by steady state

$\Rightarrow$ Overconstraining assumptions

Transient feasible
Steady state infeas
Conclusion on Algorithm

In order to solve this hourly scheduling problem

A new approach has been developed: Two steps:

1- Initialization (steady state computations)
2- Optimization phase (transient computations)
   enhancing solution / finding solution if phase 1 failed providing feasible /
   proving optimality of initialization

Solutions found in 2 minutes on a PC!!

⇒ Used during the day to adapt schedule to real life conditions
⇒ Used on a day ahead mode to prepare the day after and dimension
   flexibility contracts
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Benefits in operations

- Intraday:
  - MinOPEX: new compression set up in case of dramatical change
  - HELP: new trajectories computed each hour, on demand if needed to help operators decide how to handle the network

- Knowing better the limits of the network
Overview of HELP: a global view of the network at a given hour

Linepack variation within pipelines

Linepack variation within meshes

Real life vs forecasted
Specific view: seeing the trajectory in a mesh

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**Evolution du stock (10^3 m$^3$)**

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**Variation horaire du stock (10^3 m$^3$)**

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Conclusion on HELP

- Transient optimization in practice, used daily

- Whole integrated software:
  - From reconstruction to desired target
  - Day ahead preparation based on forecasts
  - Intraday operations adjustments
Conclusion: GRTgaz optimizes its operations using 2 softwares: MinOPEX & HELP

- TODAY at GRTgaz: a combination of two decision help tools:
  - MinOPEX: Optimized compression schemes on a daily basis
  - HELP: Optimized linepack usage and flexibility sourcing, on an hourly basis

- Working together:
  - MinOPEX: savings at GRTgaz $\sim 11$ M$/$ (2013 over 73 M$ of compression costs)
  - HELP: savings at GRTgaz $>2.5$ M$/year
Thank you for your attention

Questions?

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Meet GDF SUEZ @ Booth 23 in the Conference Hall