Optimization Based Approach for Managing Enterprise-Wide Business Planning in a Petrochemical Industry

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Outline

- Planning problem in petrochemical industry
- Business planning decisions/ issues
- Planning application requirements
- Example
- Summary
Supply Chain Planning Problem

Environment for:
- data access
- decision supports:
  - strategic planning
  - production planning
  - logistics
  - business performance analysis

How to make the most profitable decisions?

How to reduce cost? How to improve productivity? How to improve business?

Suppliers  Inventory  Resources  Inventory (Warehouses)  Customers
Horizontal Decision Complexity

- Horizontal interactions in supply chain decisions
  - Flexibility of operation options
  - Function of time

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**Suppliers** ➔ **Feedstock** ➔ **Production capacity** ➔ **Inventory** ➔ **Logistics** ➔ **Sales** ➔ **Customers**

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**Plants** ➔ **Warehouses** ➔ **Materials & Information Flow** ➔ **Sales** ➔ **Customers**

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Vertical Decision Complexity

- Vertical interactions in supply chain decisions
  » Consistency – Planning, Scheduling & Real Operation

Information Access Point

Optience SCMart Suite for Business Management

Strategic Planning

Information Details

Production Planning

Benefits Opportunity

Production Scheduling

Business Monitoring

**OPERATION**

Optience SCMart Suite for Business Management
Integrated Petrochemical Business

Upstream
- Refinery
  - Ethylene Plant
    - Naphtha
    - Others
  - BTX Plant
    - BZ
    - TOL
    - XY
  - Power Plant
  - ETY
  - PPY

Intermediate
- VCM
- SM
- TPA
- BPA

Downstream
- PE
- PP
- PVC
- PS
- PET
- PC
- Others

Others
Upstream/Intermediate Business

- Supply chain planning decision at each business unit

Diagram:

- External product purchases
  - Raw Materials
    - Internal
      - #, $
    - External
      - #, $, $
  - Products
    - Internal
      - #, $
    - External
      - #, $

? : opportunity for optimization (decisions)
Downstream Business

- Raw Material Purchasing
- Production Step 1
- Process Grades
- Production Step 2
- Product warehouses
- Logistics
- Sales

- Raw Material Stock
- Process grades
- Silos
- Sales grades
- Additives

- Sales
- Off-Site
- On-Site

- Customer 1
- Customer 2
- Other customers

- Internal demands

: opportunity for optimization (decisions)
Planning for Integrated Petrochemical Business

Upstream
- Refinery
  - Naphtha
  - Others

Intermediate
- Ethylene Plant
  - ETY
  - PPY
  - BZ
  - TOL
  - XY
  - VCM
  - SM
  - TPA
  - BPA

Downstream
- PE
- PP
- PVC
- PS
- PET
- PC
- Others

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Challenges in the integrated Planning Problem

Problem characteristics

- **Upstream/intermediate processes**
  - Operation
    » Continuous
    » Few products - co-productions
    » Simpler product distributions
  - Challenges
    » Non-linear – Blending/mixing, Yield performance
    » Combinatorial – Operational constraints

- **Downstream processes**
  - Operation
    » Continuous/ batch
    » Many products – Product recipes/ Product allocations
  - Challenges
    » Complex resource allocation, product inventory and distribution management
Business Planning Decisions (1/3)

- Raw material purchasing
  - What material, How much, From which supplier & When?
    - Need to consider
      » Prices, logistics, inventory level, business policy

- Raw material storage
  - Storage management – today & future operation plan
    - Need to consider
      » Allocation for new arrival and feeding to production lines/plants
      » Manage inventory level for all storages

- Production
  - What to make, How much, Which plant & When?
    - Need to consider
      » Availability & capacity of plants, production efficiency
      » Product inventory & demands
Business Planning Decisions (2/3)

- **Product storage/warehouses**
  - What product, how much to keep, where?
    - Need to consider
      - Demands, productions, logistics

- **Logistics**
  - Logistic cost management – today & future operation plan
    - Need to consider
      - Demands, Inventory at each warehouse, production

- **Sales**
  - What product, how much, prices, where & when?
    - Need to consider
      - Production & inventory
      - Logistics cost, business policy
Business Planning Decisions (3/3)

All of the above decisions are related & have impacts on overall profit

Need to consider the trade-off of key decisions simultaneously
Issues in Planning Problem

- Understanding the impacts of uncertainty
  - Price changes
  - Demand changes
  - Capacity changes
  - Business policies
    - Inventory
    - Product allocation

- Require sensitivity analysis
  - Create case & sub-cases
    - Impact of changes on profitability
How do we make a decision for Enterprise Wide Business Planning?

Need an optimization based application? What kind?
Problem representation/ Modeling capability

- **Problem scope**
  - Modeling of upstream to downstream businesses
    - In the same environment as one model

- **Modeling approach**
  - Concise problem representation
    - Unit operation based approach
    - Automatic mathematical model generation – data driven
  - Multi-level modeling
    - Support multi-level model aggregation – different applications

- **Modeling capability**
  - Mathematical programming approach
    - Model for linear, nonlinear & combinatorial problem (LP, NLP, MILP & MINLP)
    - Robust optimization solution engines
Planning Application Requirements (2/2)

ý Data/ model management

• Data I/O
  – Efficient data transfer/ viewing
    » Open database architecture

• Data viewing/ analysis
  – Efficient environment for data viewing & analysis
    » Rapid UI development environment

ý Supporting workflow

• Model/data – communication & sharing
  – Multi-level application
    » Planning & Scheduling
  – Cross-department
    » Purchasing, Planning, Sales, etc..
Example of Applications

Ethylene Business Planning & Scheduling
Ethylene Business Optimization Opportunity

A Business Scenario

Feedstock Info

Yield

Light

Heavy

NAP Cost

Optimal NAP ratio (L/H)?

Ethylene Plant

Feedstock Info

Yield

Light

Heavy

NAP Cost

Optimal NAP ratio (L/H)?

Ethylene Plant

Ethylene Plant

Inventories

ETY

PPY

ETA

BBP

GSL

Demands

Business Policy:

Market Dependent

Process Dependent

Market Dependent

Optimize Decisions – for now and future

Resource Knowledge

Business Policy

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Main Focus:

Find optimal feedstock *purchases* for production planning, for meeting production demands.
Optimization - Ethylene Production Scheduling

Main Focus:
Find optimal feedstock *allocation* for daily production scheduling, for meeting production demands

Scheduling:
- Accurate (rigorous) daily production model
- Mixed Integer Nonlinear optimizer
Model Representation – Planning
Model Representation – Scheduling
Planning Application

Planning result – summary

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<th>Product</th>
<th>Production</th>
<th>Percent</th>
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Planning Application

Feedstock purchasing & planning workflow
Scheduling Application

- Scheduling result – summary
Multi-Products Business Planning & Scheduling

Example – Polymer business
Example: Multi-Products and Multi-Sites Planning
Example – Modeling in SCMart Modeler
Business Performance Monitoring & Analysis

Example – Multi-products business
Business Performance Monitoring

- Data sharing & performance analysis
  - Custom view for each department

Diagram:
- Optience Core
- Databases for Business Management
- Sale Dept.
- Business Dept.
- Planning Dept.
- Purchasing Dept.
- Production Dept.
- Logistics Dept.
- any other dept.
Sample View - Products

- Group by product class, product list
Sample View - Customers

- Group by regions
Sample View - Sales

Total – by region
Sample View - Inventory

- Total, by warehouse, product class, product
### Sample View – Shipping Cost

**By regions**

#### From Warehouse W1

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<th>Region</th>
<th>Average Cost</th>
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<tr>
<td>2002</td>
<td>Y</td>
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Sample View – Sales Analysis

- Top 20% most profitable products ($)

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Enterprise Wide Business Planning

Example – OA & PO business
Integrated Planning – OA & PO Business

Model representation

- OA (Olefins-Aromatics)
- PO (Poly-olefins)
Integrated Planning – OA & PO Business

Result – PE capacity (sub-cases)
Integrated Planning – OA & PO Business

Result – Profit
Integrated Planning – OA & PO Business

Result – on Naphtha selections
Integrating Planning – OA & PO Business

Result – OA demands

- Ethylene Demand
- Propylene Demand
- Gasoline Demand
Summary

- Enterprise wide planning – need one system
  - For business decision support applications