# Supply Chain Management for Palm Oil Industry

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# Part I:
# Network Synthesis

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

# Network Management

- Integrated planning of the activities in a supply chain
- Planning and control of flow of goods, services, money, and information
- Allows customers and suppliers to partner together
  - Maximize responsiveness and flexibility
  - Reducing costs and paperwork
  - Gain sustainable competitive advantage

# Objectives of Network Management

- Examine the netowk participants
- Acknowledge the interrelationships among business processes that support the network
- Recognize how business intelligence tools are used in decision analysis

- Can be maintained by manufacturer
  - Continuous replenishment
  - Can link into POS systems
- Cross-docking
- Creates linkages between supplier and retailer
  - Lower costs
  - Better customer service
  - Increased profitability
- Information sharing along supply chain
  - Translates sales transactions into production processes and material requirements

# Network Relationships

# continued

- Benefits
  - Cost reduction
  - Inventory reduction
  - Cycle time improvement
  - Improved customer service
- Integration requires commitment to strategy, process, organization, and technology
  - What linkages should be established
  - Communications
  - Data integration

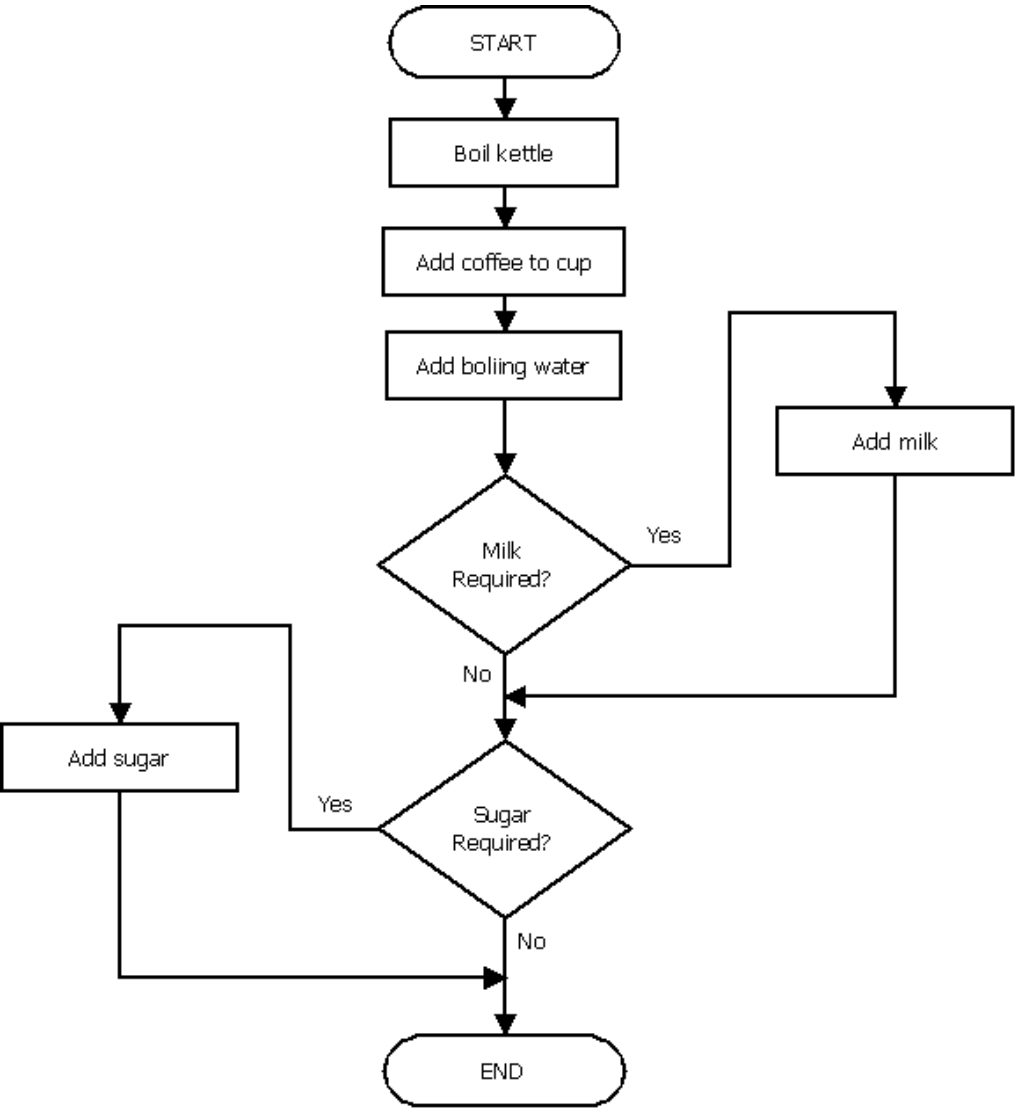
# Process Network Synthesis

- Process Network Synthesis  (PNS) is the combination of all feasible process pathways and solutions creates a huge super structure.
- Objective: optimum solution and flexible alternative solution is always challenging.

# Start from a simple example: Coffee making

# Raw materials, intermediates, products

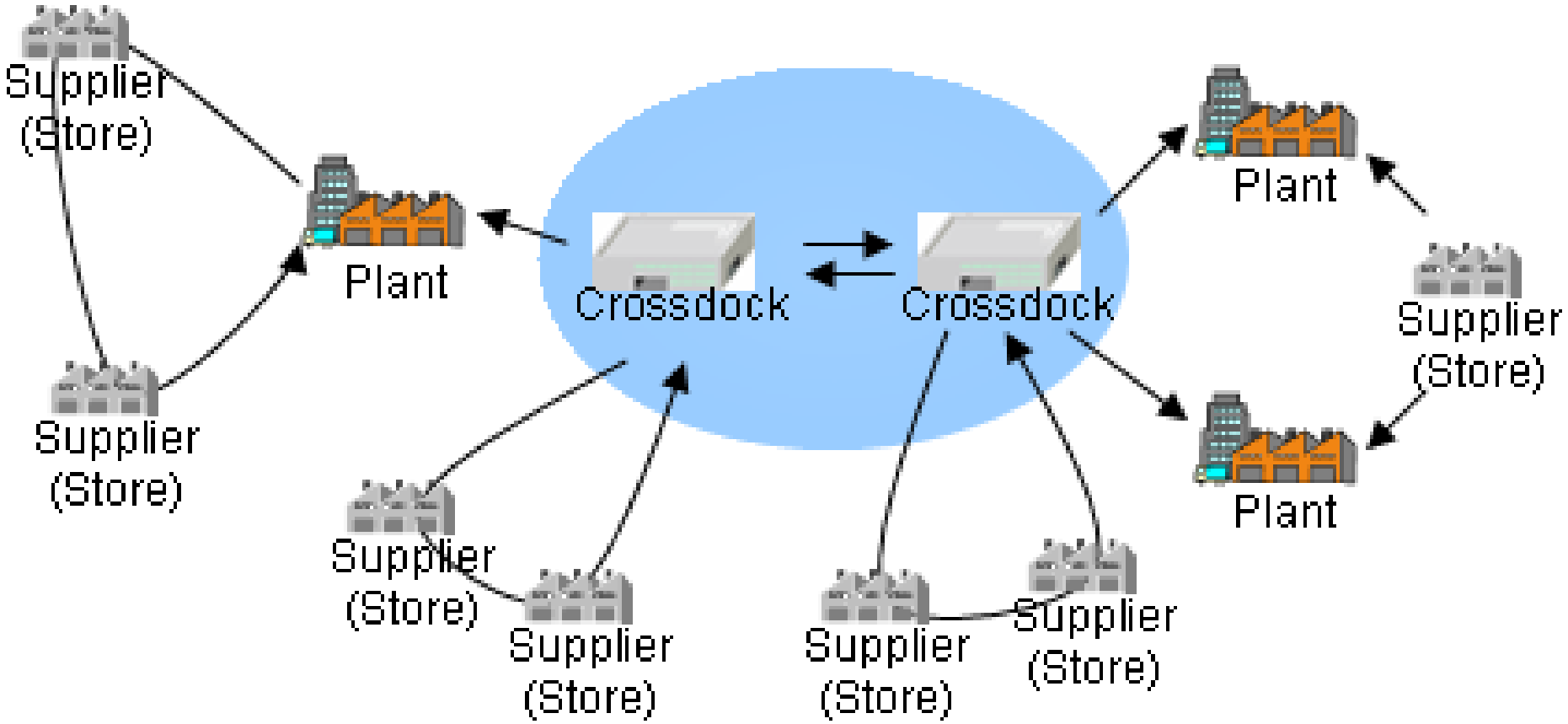

# Make your Coffee now!





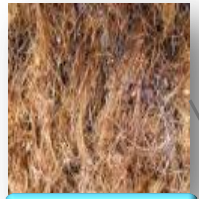

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

# Key answer to Network solution: 5W Why, Where, Who, What, How




EFB


PKS


PMF


OPF


Pelletising


Briquetting


DLF Production


Carbonisation


Fermentation


Boiler


Steam Turbine


Pellet

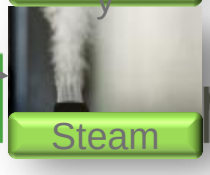

Briquette


DLF

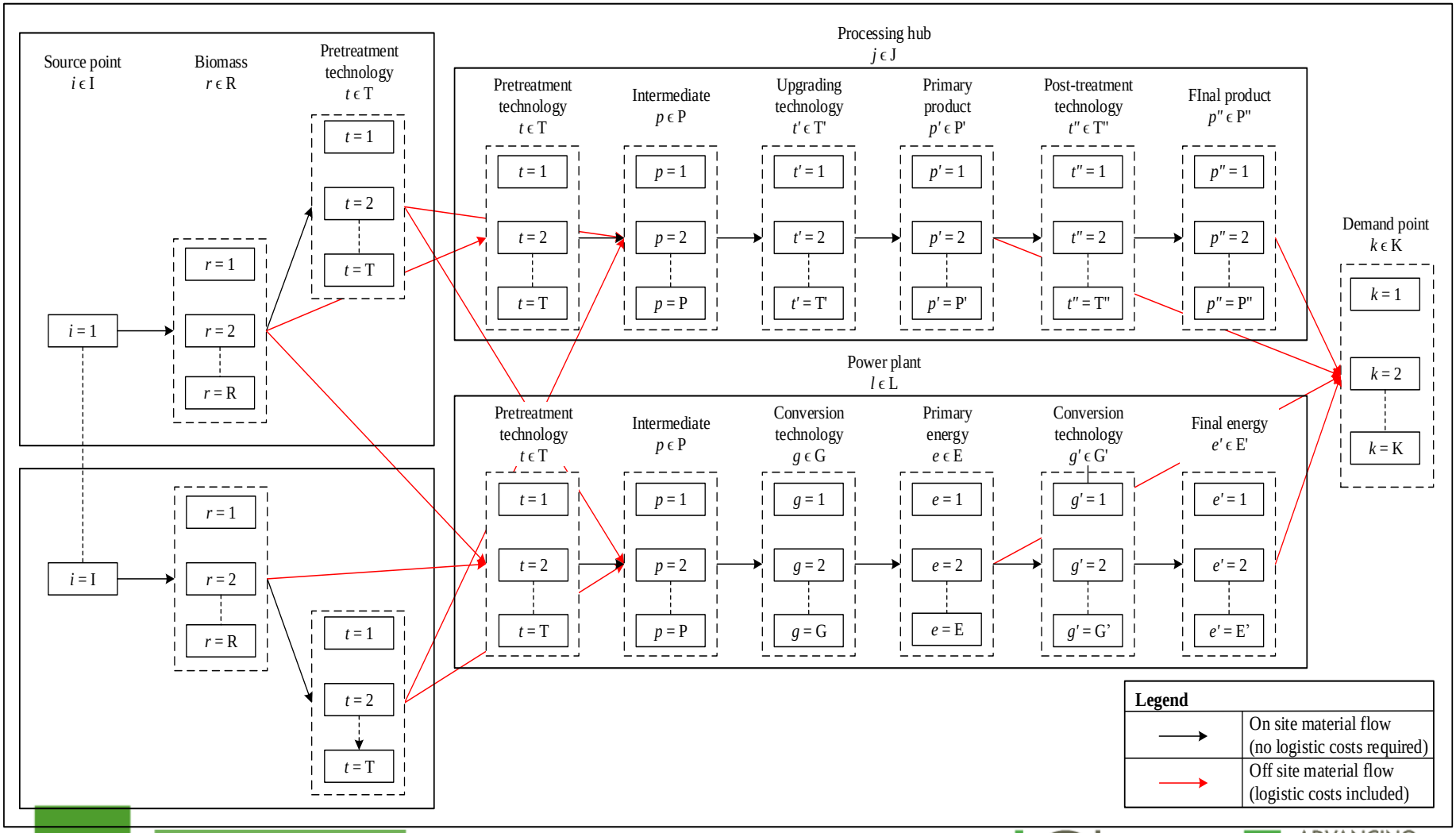

PKS Charcoal

Ethanol


Electricity

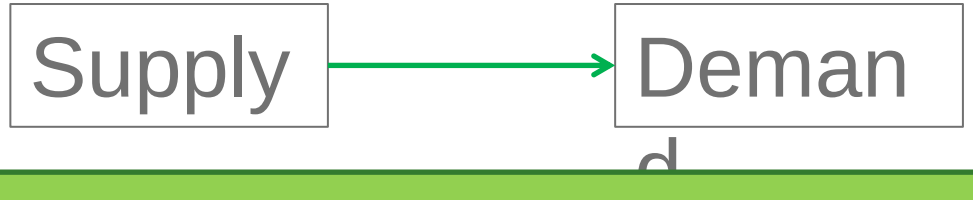

Steam

# Generic superstructure



# Part 2:
# Basic linear programming for PNS

# Basic Network Model




Observe supply limit: $\Sigma_j x_{ij} \leq a_i$

Satisfy demand: $\Sigma_i x_{ij} \geq b_j$

Objective function: minimise $\Sigma_i \Sigma_j c \times x_{ij}$

# Algebraic Representation

***Indices (or sets):***

$i$ = plants

$j$ = markets

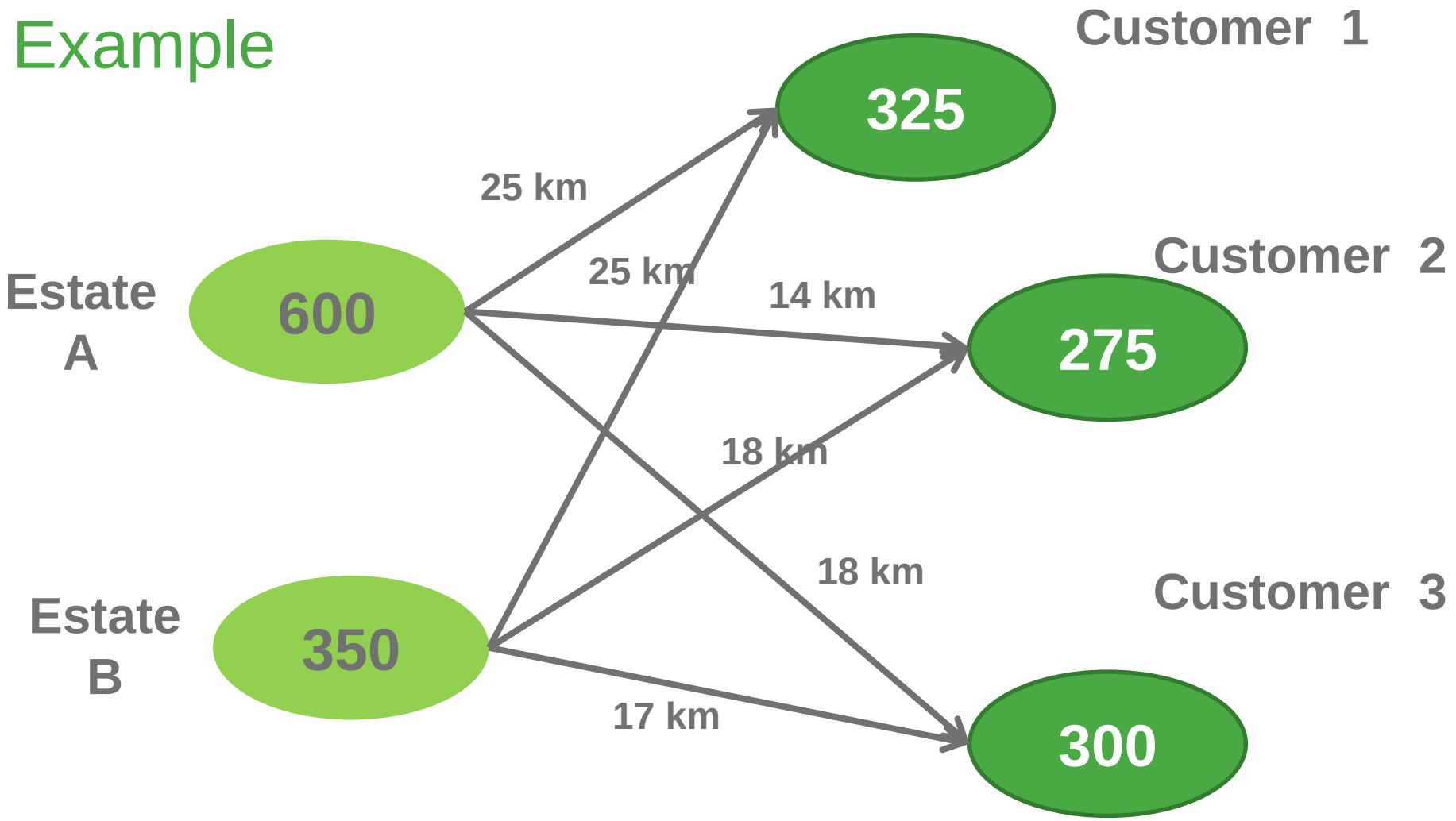
***Given Data (or parameters):***

$a_i$ = supply of commodity of plant $i$ (in cases)

$b_j$ = demand for commodity at market $j$ (cases)

$c_{ij}$ = cost per unit shipment between plant i and market j ($/case)

# Example




Minimise: Transportation cost
Subject to: Demand satisfaction and supply constraints

# What do we need as input ?

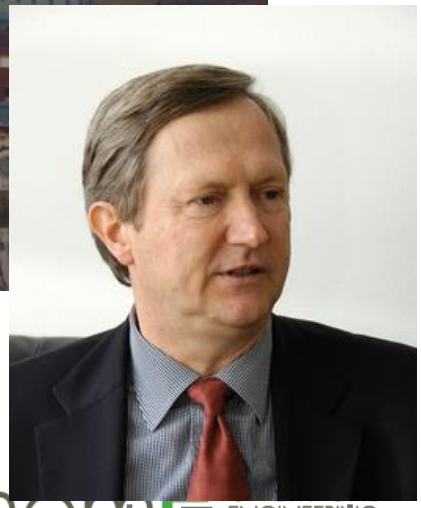
Distance/ Transportation cost

Supply

Demand

# Part 3:
# Introduction to P-graph

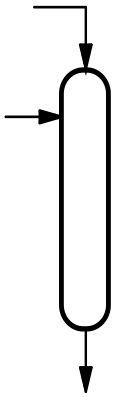
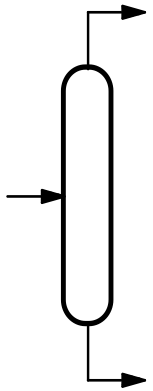
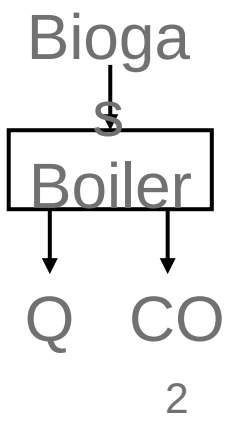
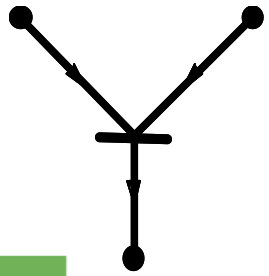
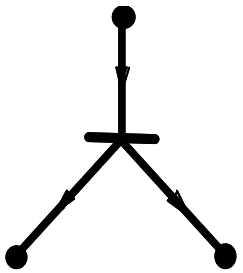
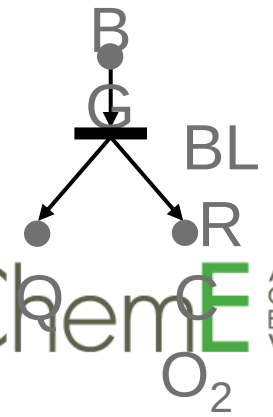
# Introduction to P-Graph

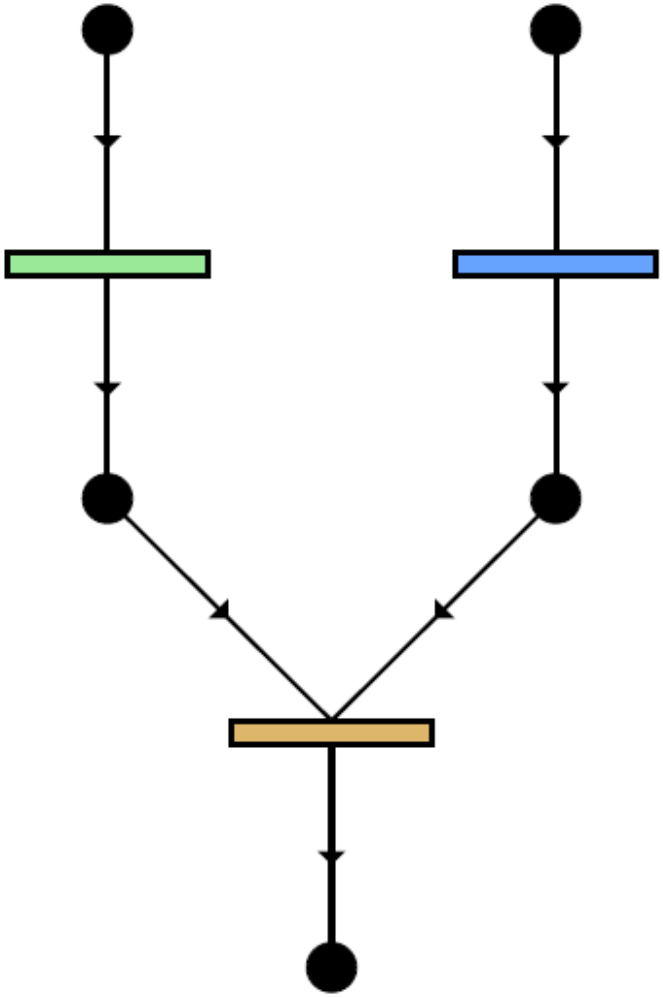


Veszprem, HUNGARY

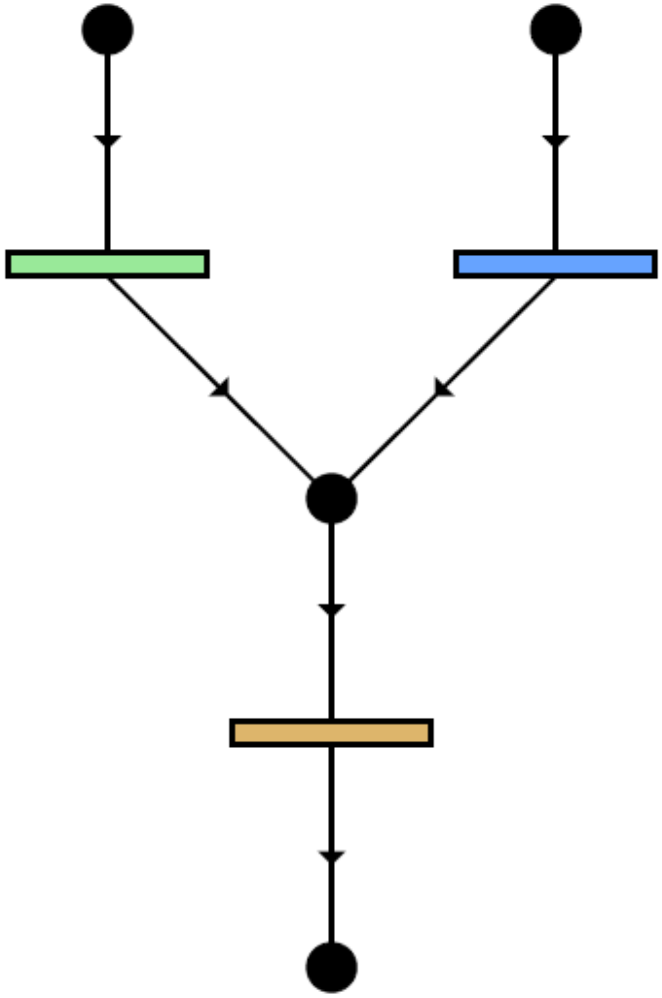
P-graph Founder,
Prof Friedler Ferenc

# P-graph vs Unit operations

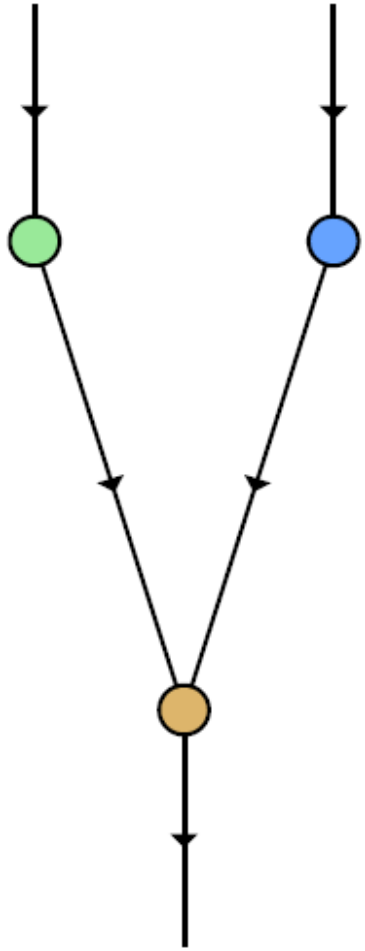
| | Reactor | Distillation column | Boiler |
|---|---|---|---|
| **Flowsheet (block-style)** |  |  |   |
| **P-graph** |  |  |   |



P-graph

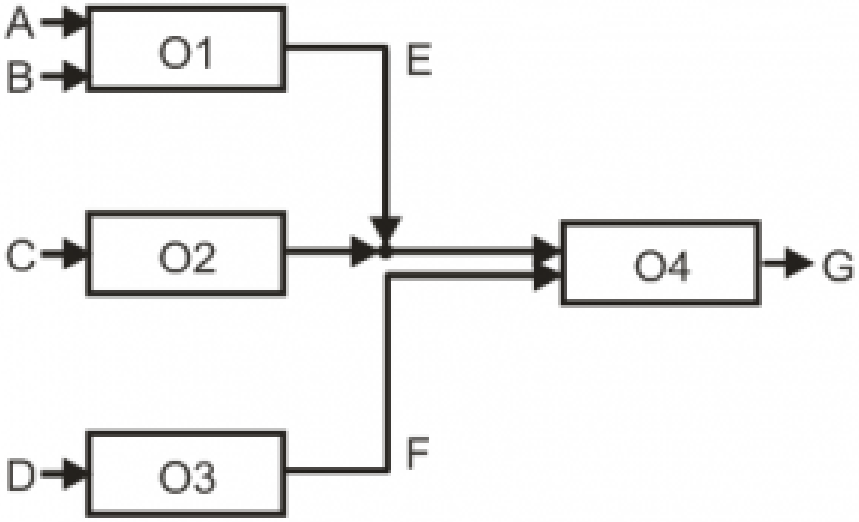


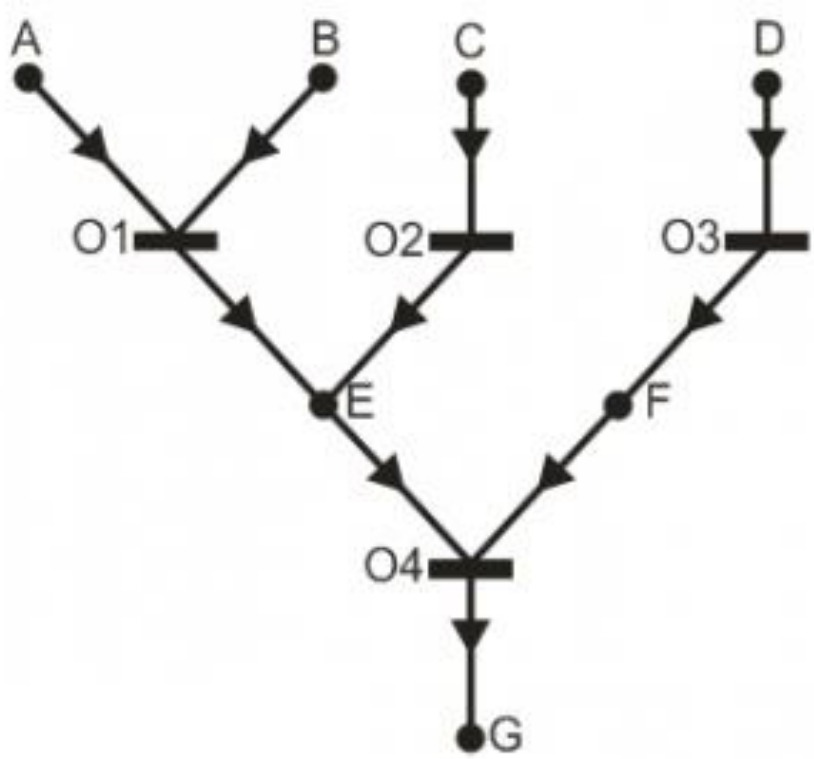
P-graph



Directed graph

# What you draw is what you get!



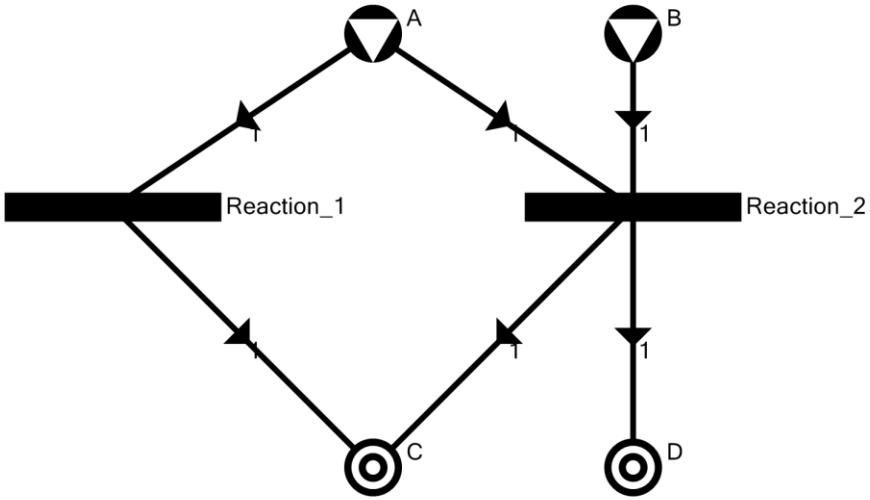



# Introduction

## *Difference between MSG/ SSG?*

- There are two reactions pathway to produce Desired Product “C”
  - Reaction 1: A→C
  - Reaction 2: A + B → C + D

- MSG:



# Introduction

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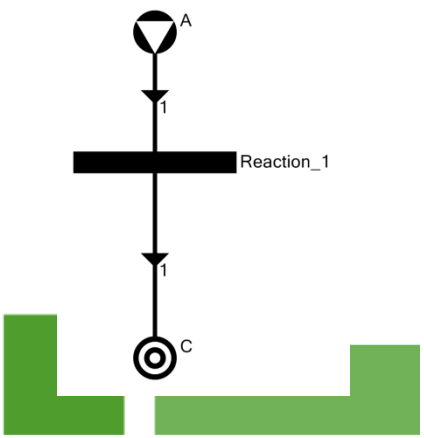
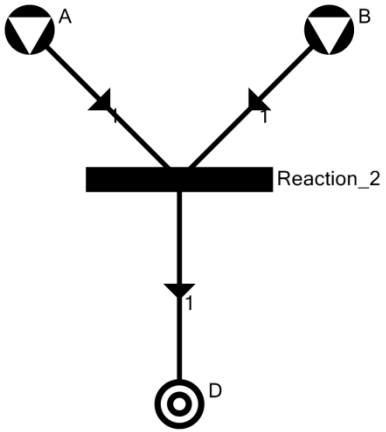
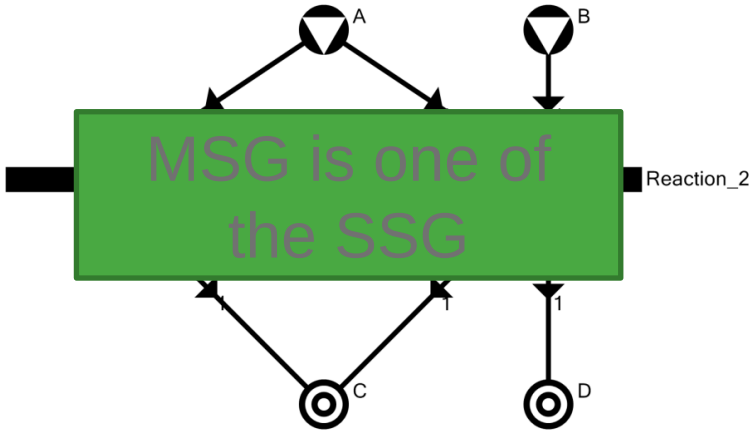
- SSG:

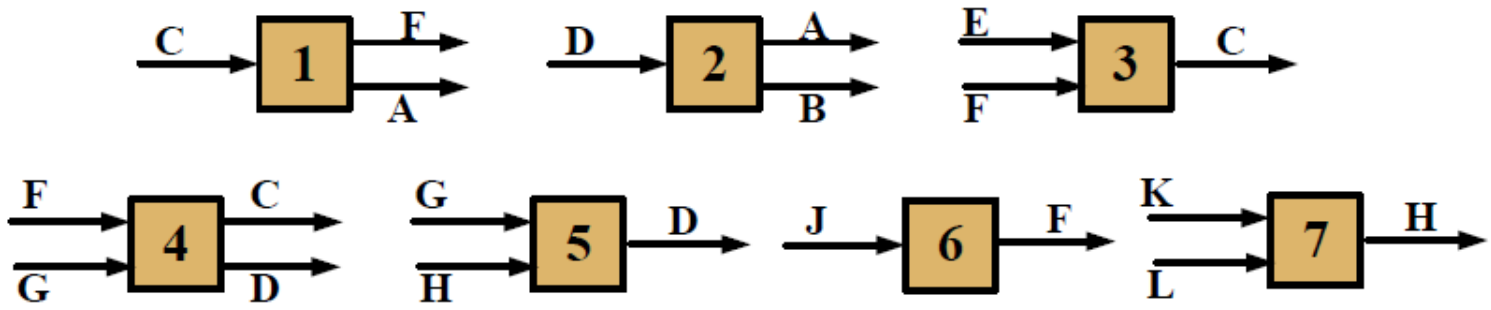


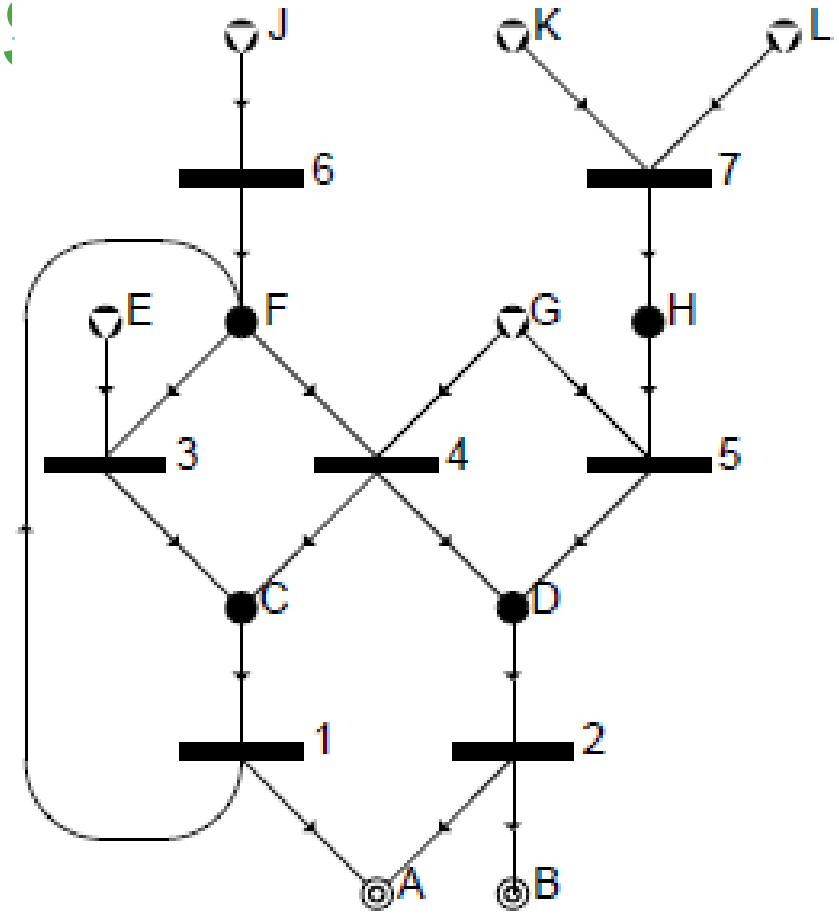
# Play a game:
## Construct a complete process network

- Operating units (unit operations):

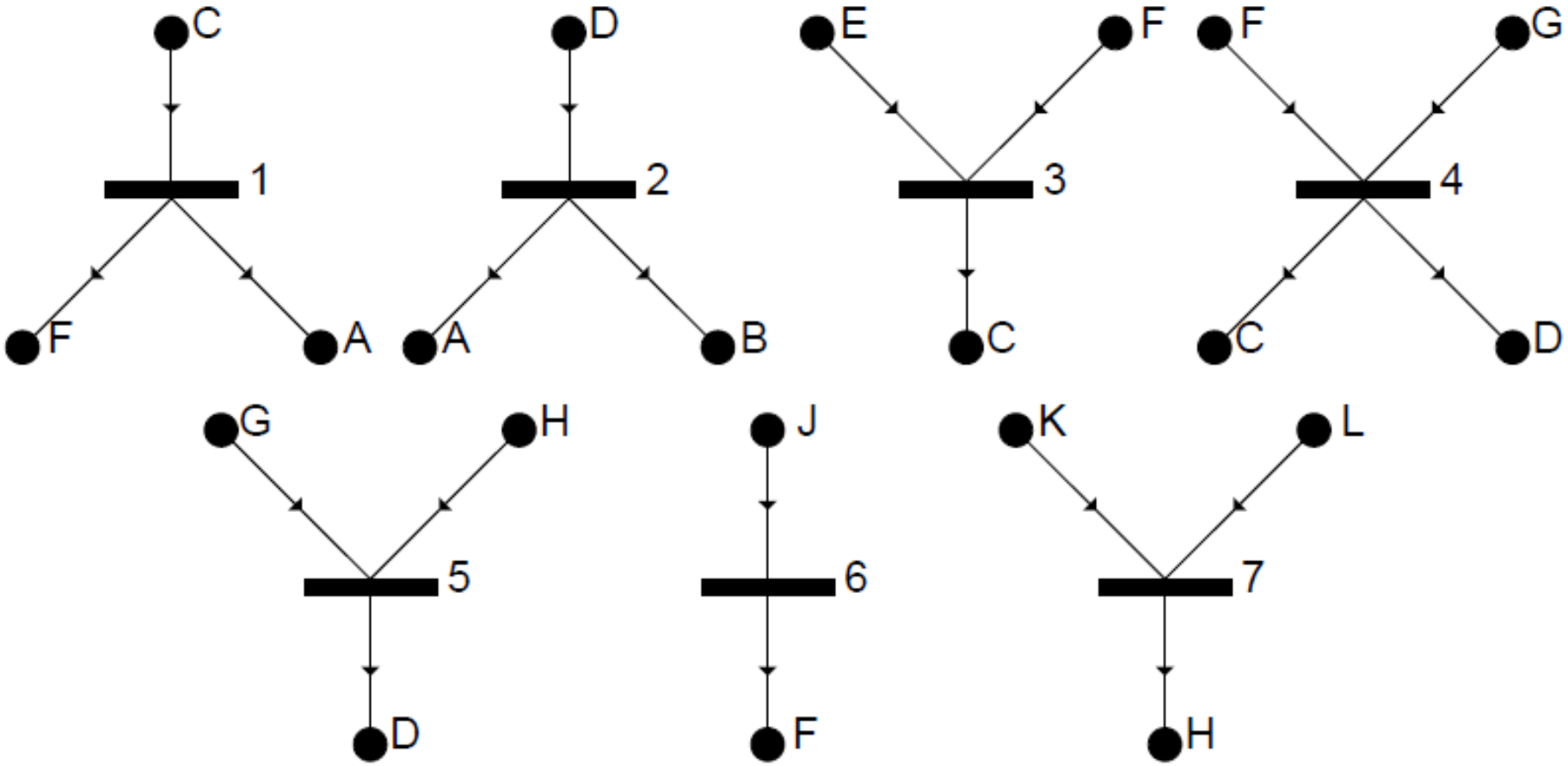



- Product: A
- Raw materials: E, G, J, K, L

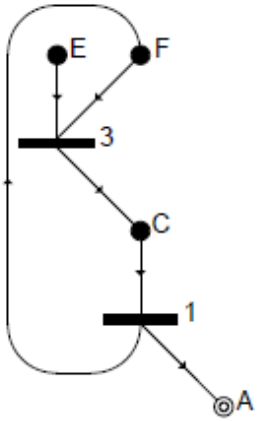
# Maximal S



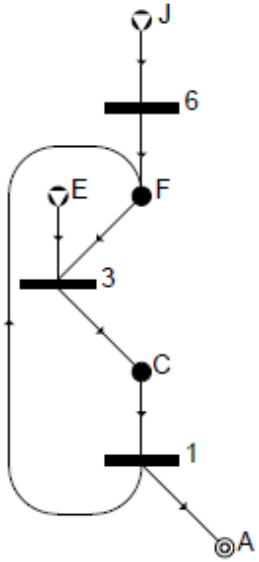
# How many feasible solutions?



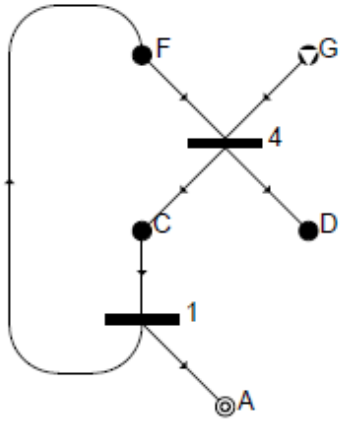
# All feasible networks



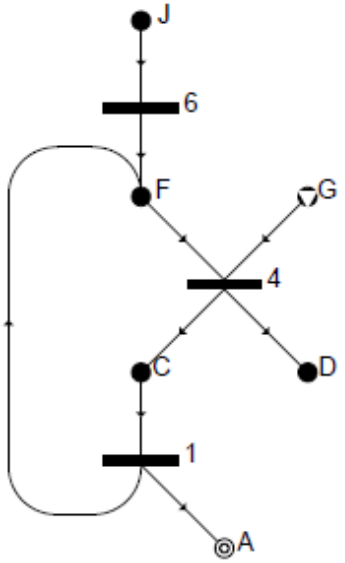

Solution #1



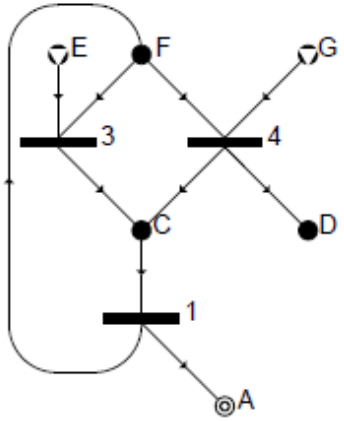

Solution #2



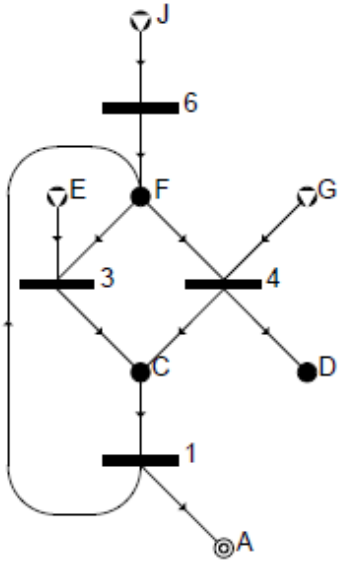

Solution #3




Solution #4




Solution #5

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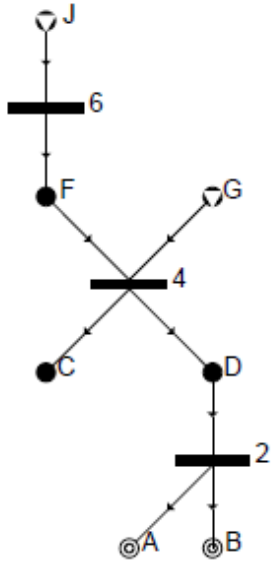


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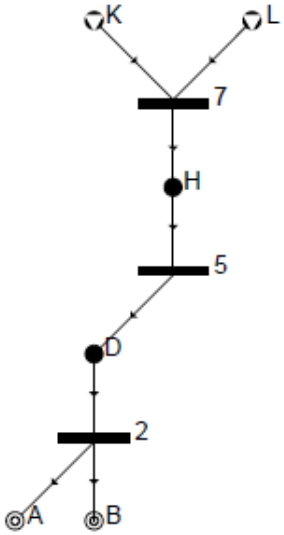
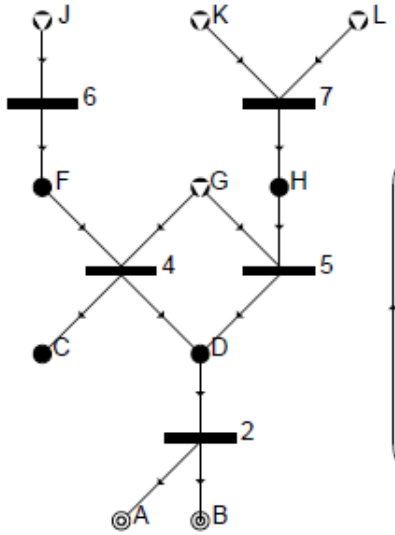
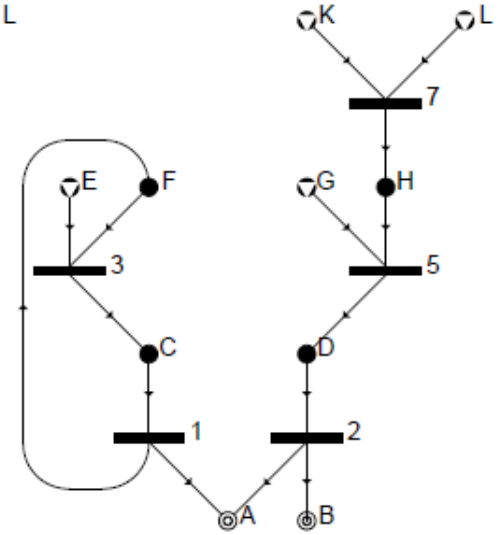


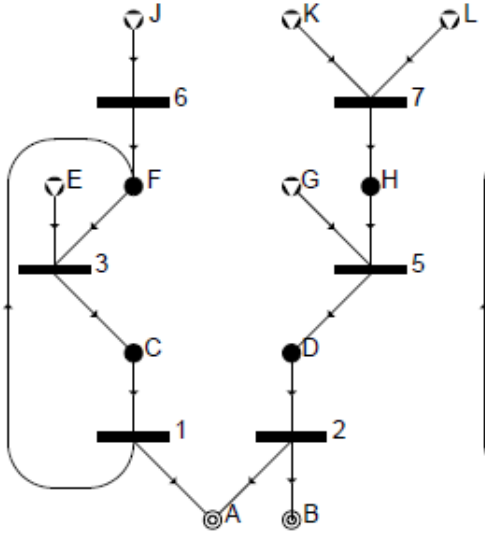

Solution #8




Solution #9




Solution #10

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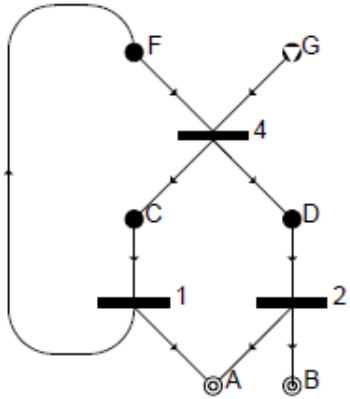
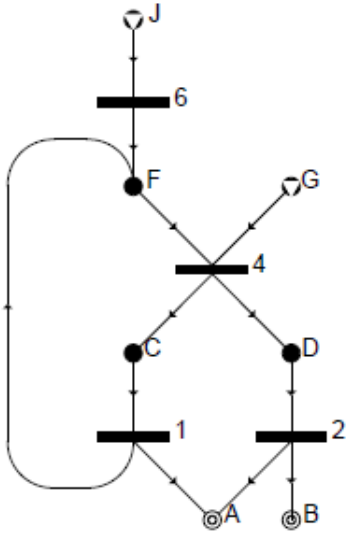
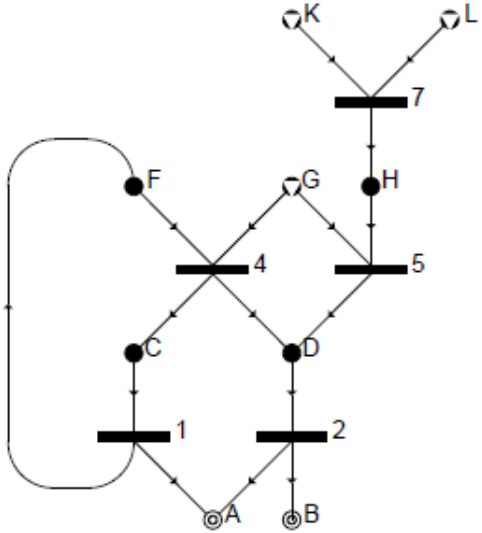


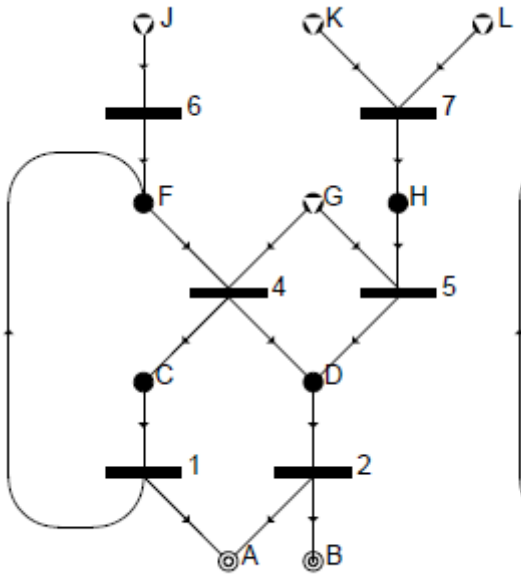

Solution #12



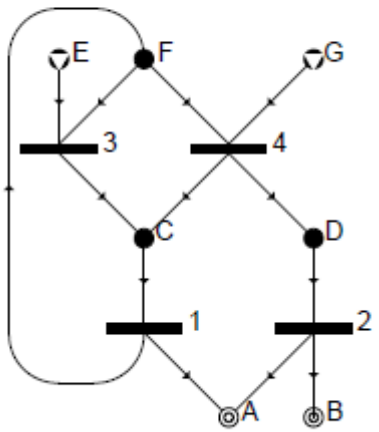

Solution #13



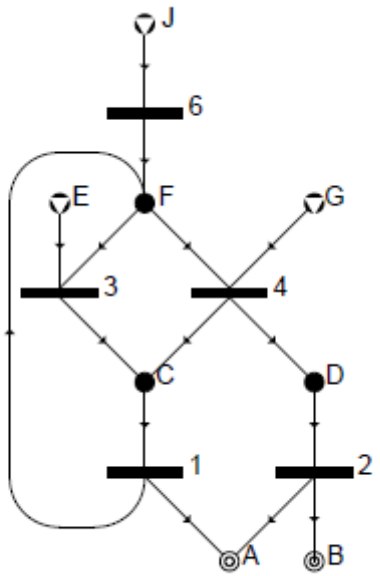

Solution #14



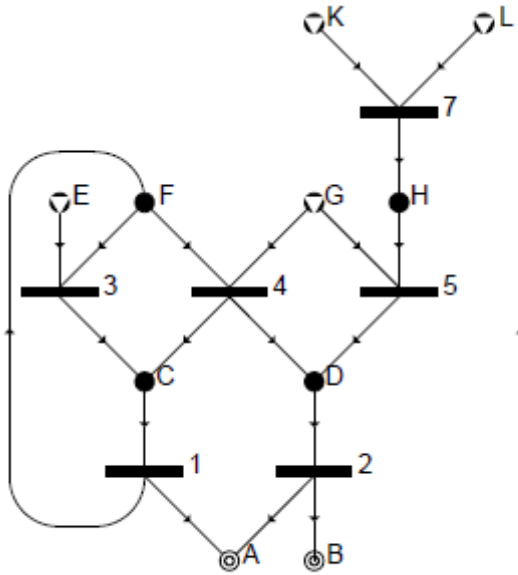

Solution #15




Solution #16




Solution #17

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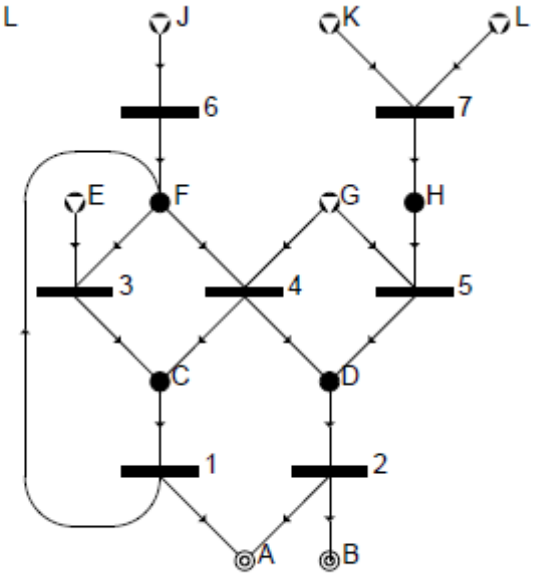
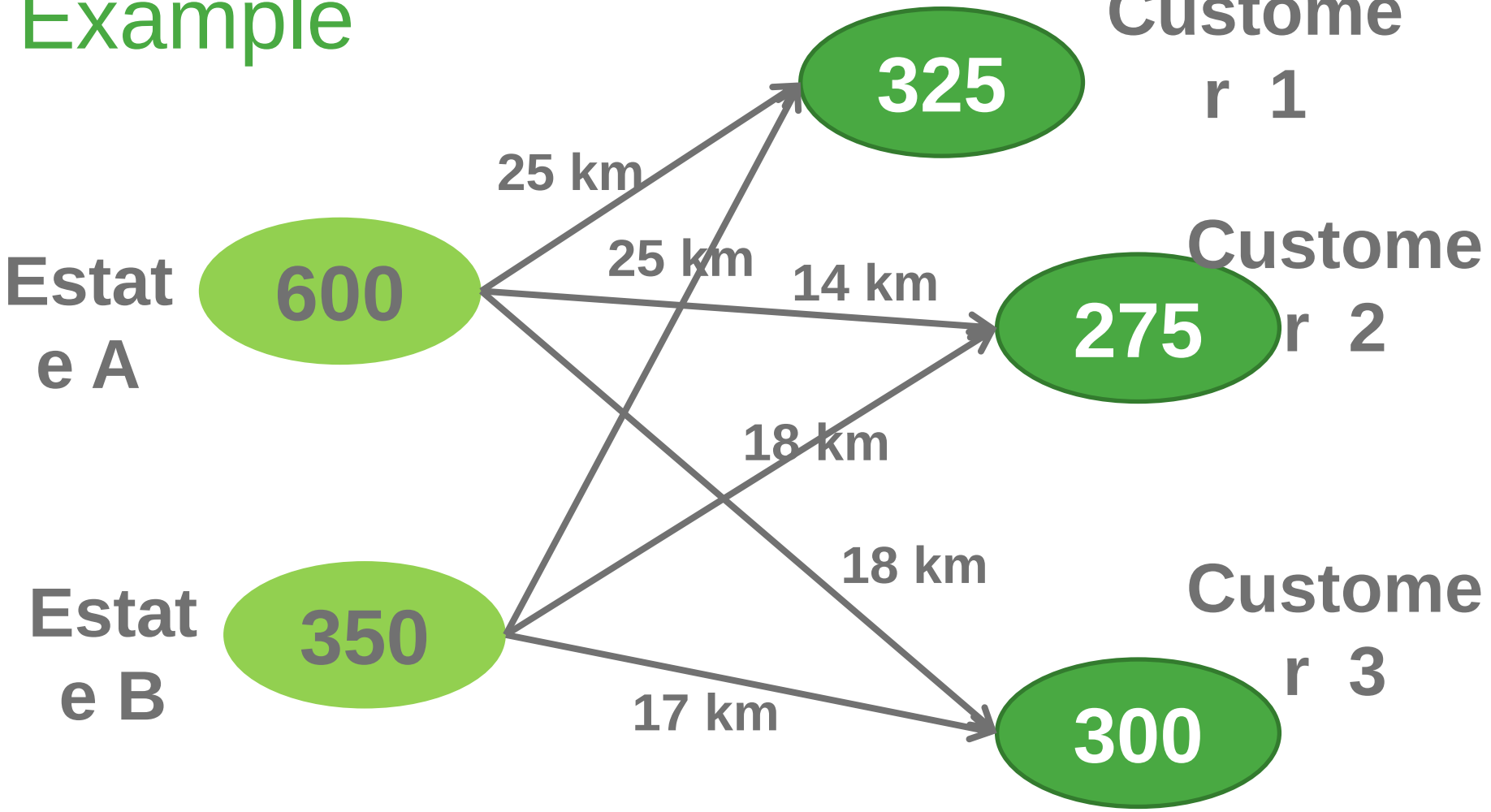



Solution #19

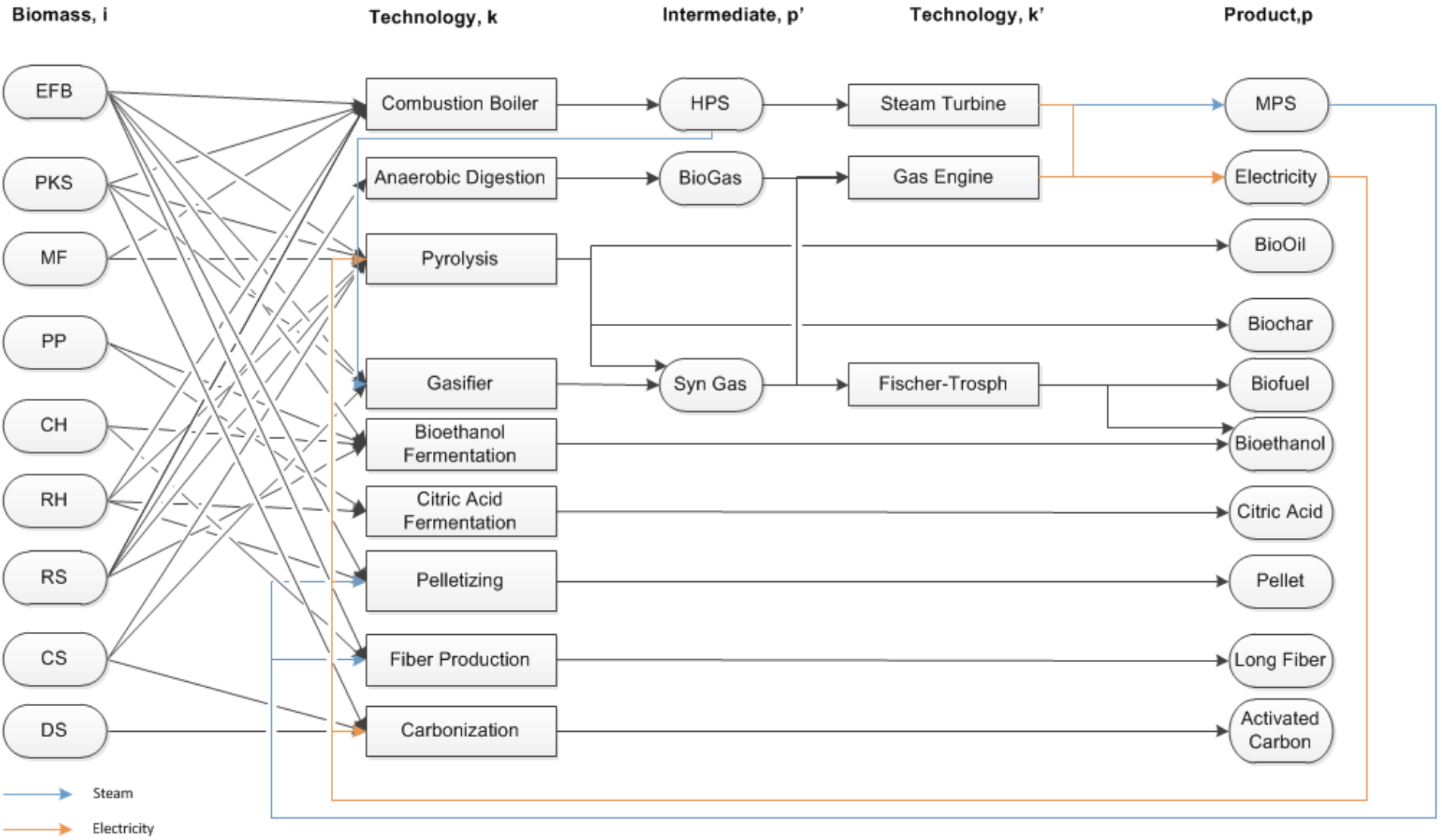
# Example



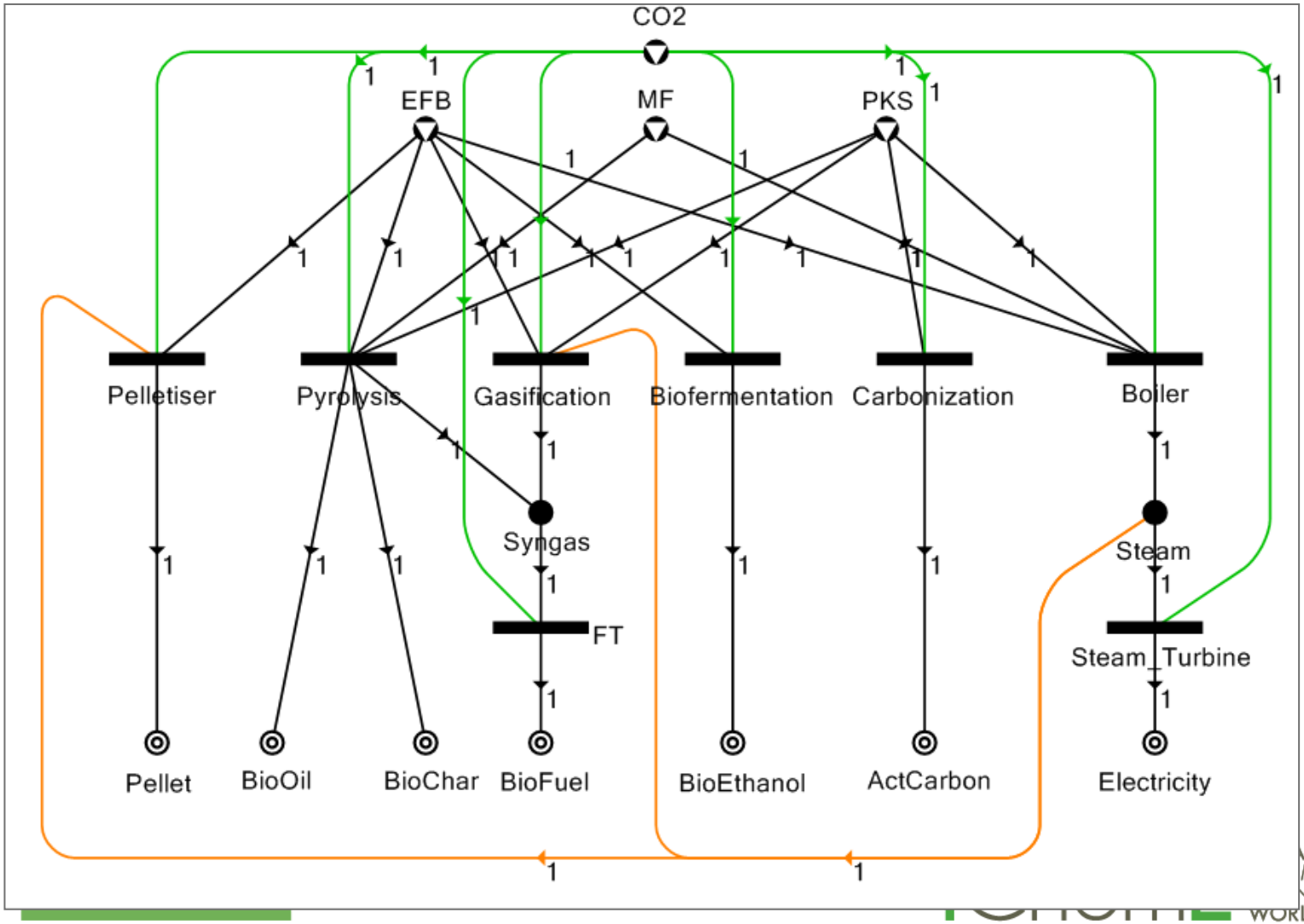

Can we draw a P-graph representation for this network?

# Part 4: Implementation of P-graph Solution

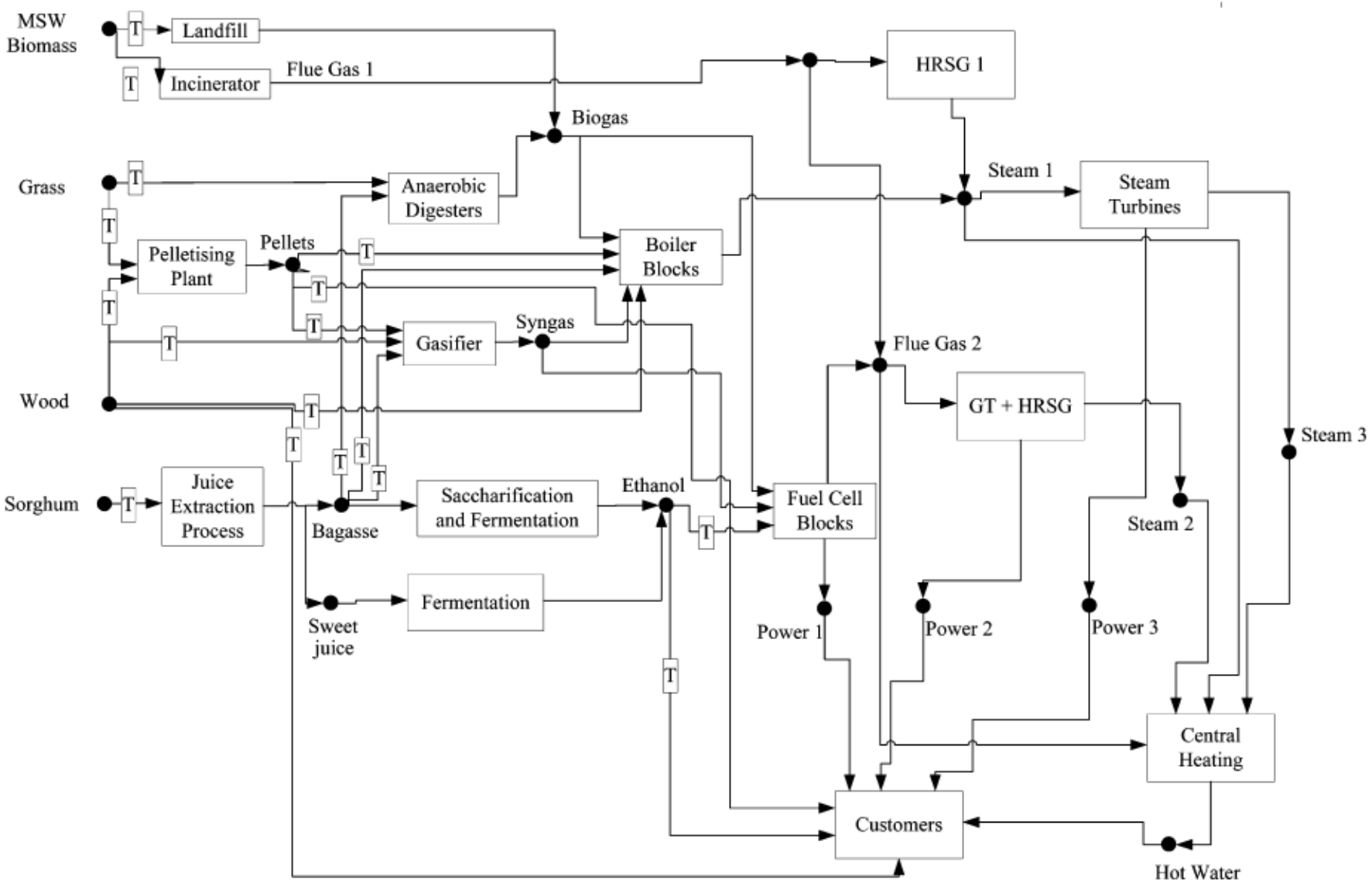
# Examples of PNS problem: Biomass Network

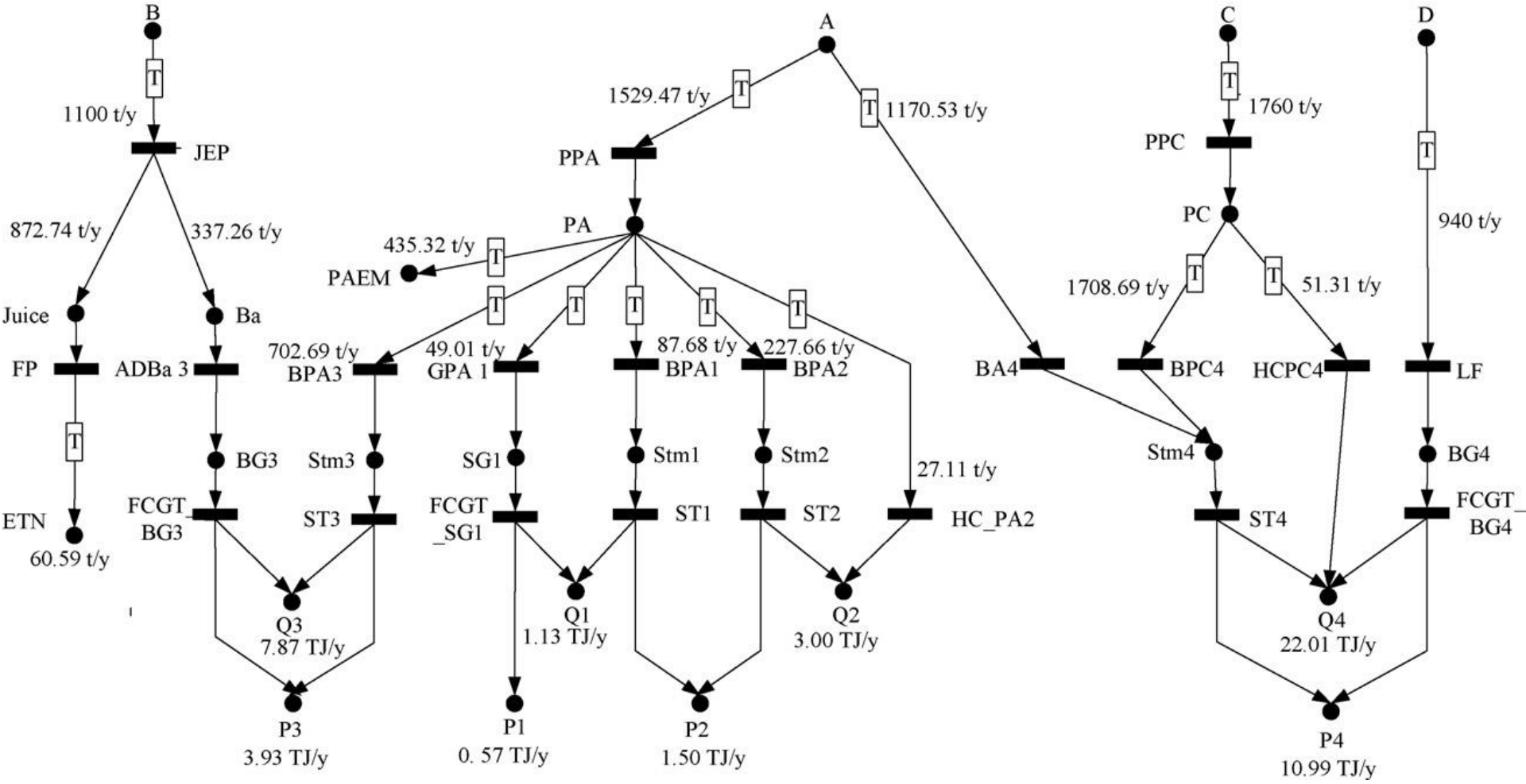


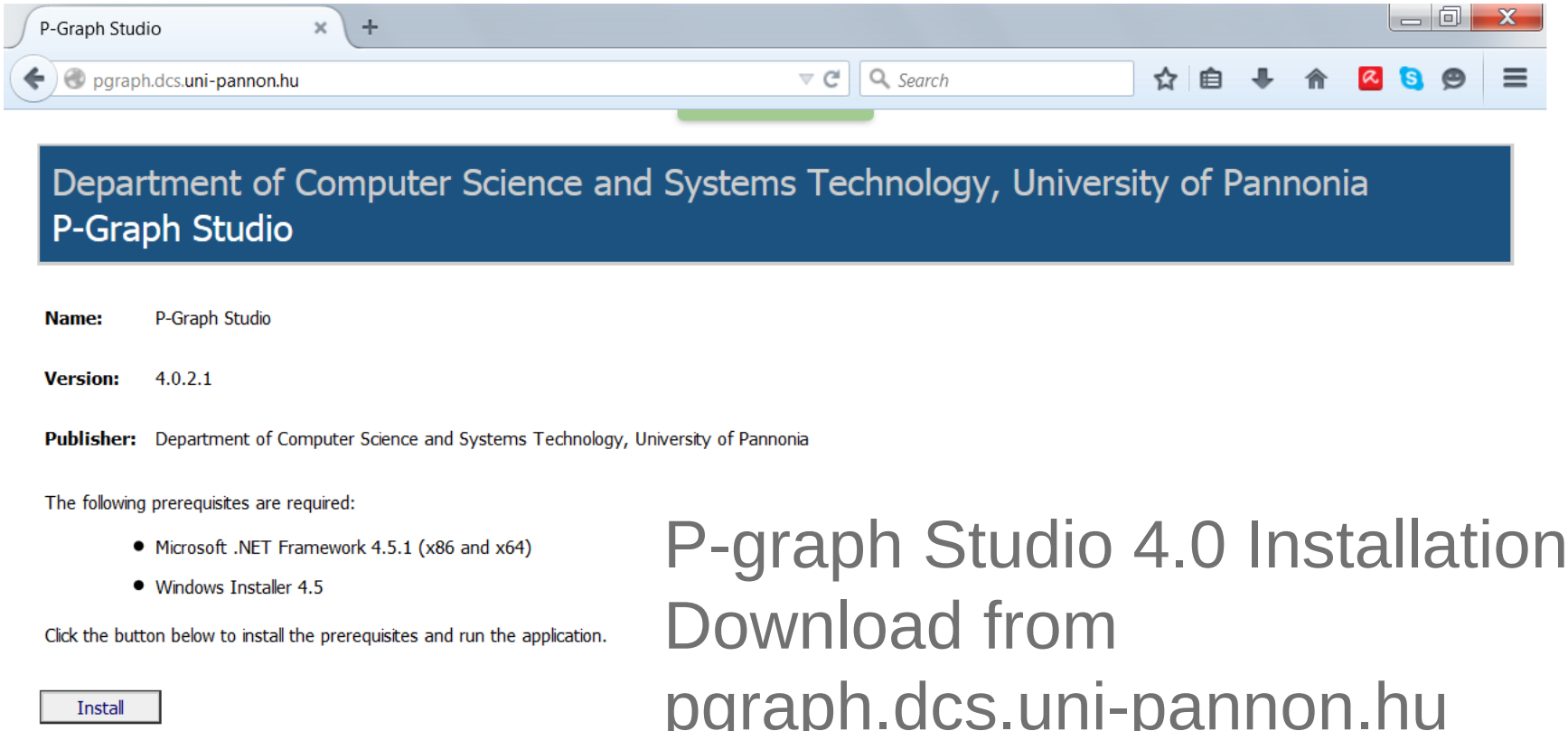
# P-graph Presentation



# Biomass Process Network




B
T
1100 t/y
JEP
872.74 t/y
337.26 t/y
Juice
Ba
FP
ADBa 3
T
BG3
Stm3
ETN
60.59 t/y
FCGT_
BG3
ST3
Q3
7.87 TJ/y
P3
3.93 TJ/y
A
1529.47 t/y
T
1170.53 t/y
PPA
PA
435.32 t/y
T
PAEM
T
T
T
T
T
702.69 t/y
49.01 t/y
87.68 t/y
227.66 t/y
BPA3
GPA 1
BPA1
BPA2
SG1
Stm1
Stm2
27.11 t/y
FCGT
_SG1
ST1
ST2
HC_PA2
Q1
1.13 TJ/y
Q2
3.00 TJ/y
P1
0. 57 TJ/y
P2
1.50 TJ/y
BA4
C
T
1760 t/y
PPC
PC
1708.69 t/y
T
T
51.31 t/y
BPC4
HCPC4
Stm4
ST4
Q4
22.01 TJ/y
P4
10.99 TJ/y
D
T
940 t/y
LF
BG4
FCGT_
BG4




# P-graph Studio 4.0 Installation: Download from pgraph.dcs.uni-pannon.hu

# Separation

Create a P-graph for:

1) 10 kg of Mixture A will be separated into B(5.5kg) and C(3.8kg) and 2kg of CO2 by a separator
2) What are the output of 500t of Mixture A being separated in the same unit

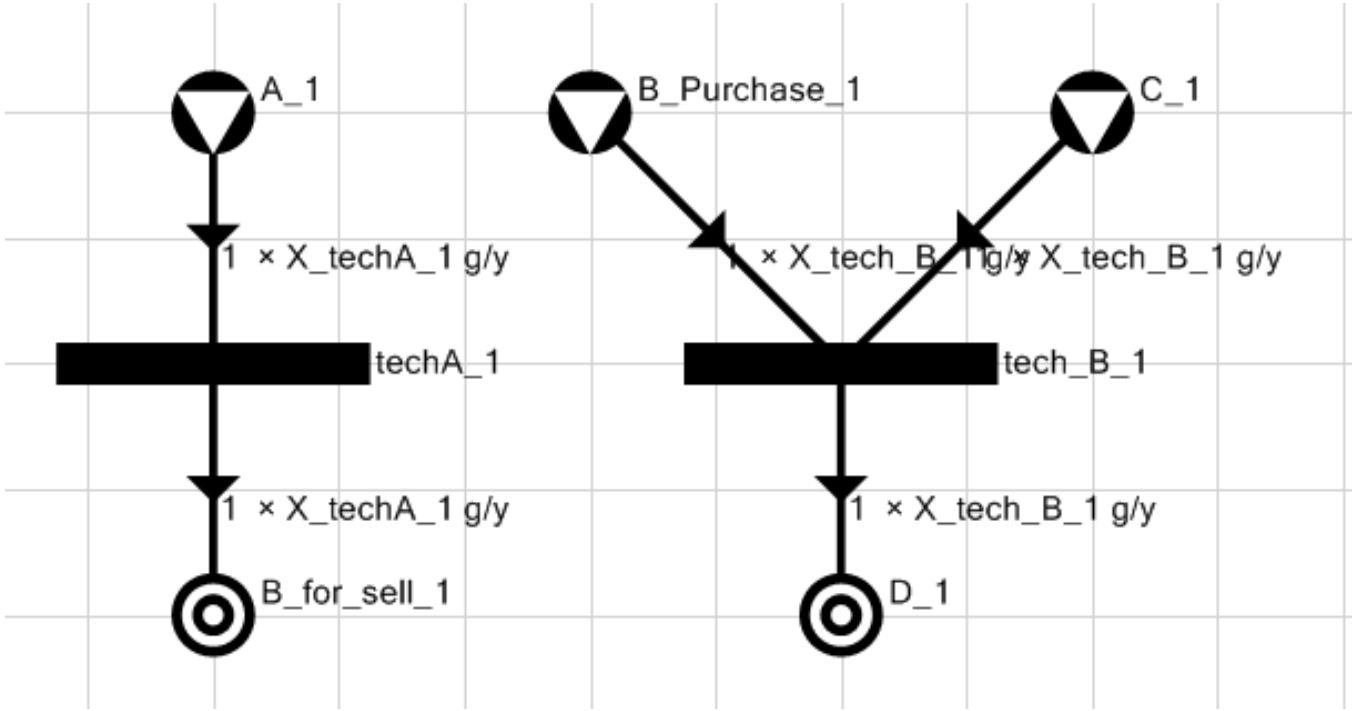
# Mixing

Create a P-graph for:

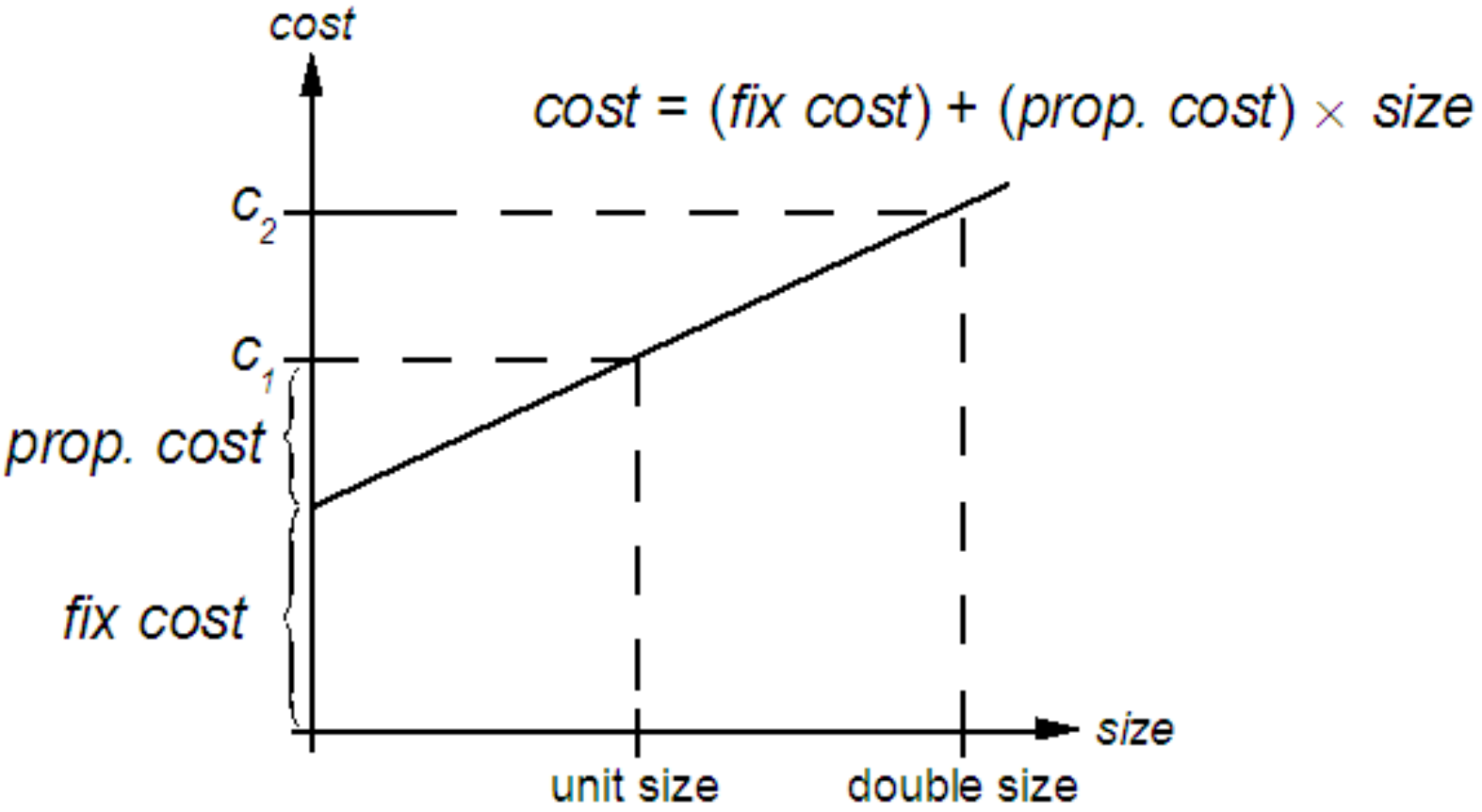
1) 10 kg of A(RM1.50 per kg)  will be compressed as pellets (9kg)
2) 10 kg of B (RM  1.80 per kg) will be cut and dried up as chips (9.5kg)
3) A burner is used to burn 15kg of biomass to heat up water.
4) What are the solution?

# Recycling

Create a complete recycle network for this example:



C



# Maximum flow vs. Required flow

# Lower vs. Upper Capacity

# Working Session: Biorefinary Solution

- Utilization of paddy biomass (rice husk)
  - Availability : 100 t/y
  - Purchasing Price: $24.38/t
  - 3 possible tech:
    1. Combustion in boiler to produce steam, and utilized the steam to generate electricity
    2. Fast pyrolysis to produce syngas, biochar, and py-oil
    3. Slow pyrolysis to produce syngas and biochar

## Conversion

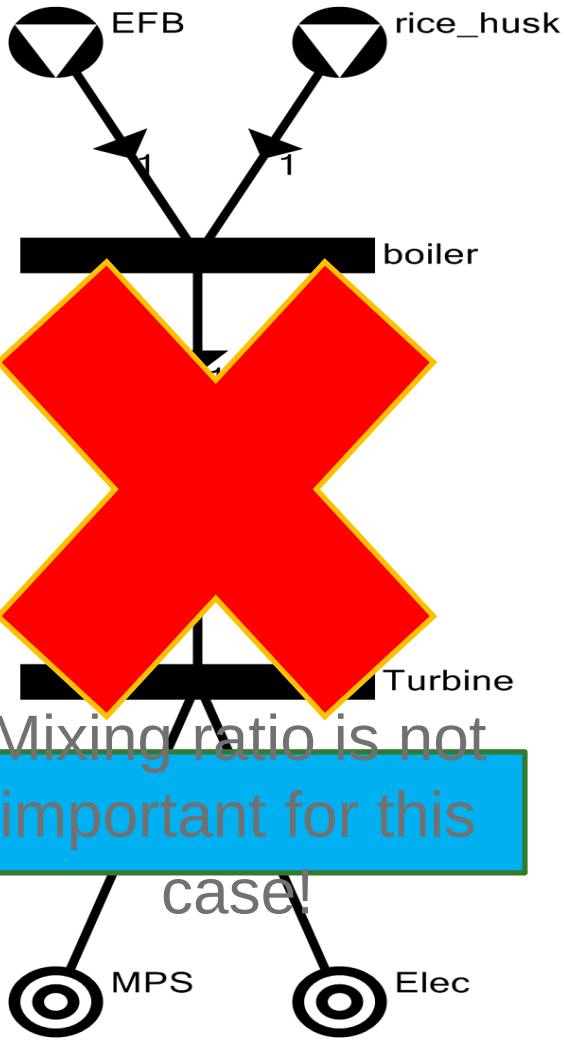
| Tech | Conversion | Elec Requirement |
|---|---|---|
| 1 | Boiler : 4.787t HP Steam/t rice husk<br>Turbine: 0.91t MP Steam/t HP Steam<br>0.58 kW/ t HP Steam | |
| 2 | 0.26 t biochar/t rice husk<br>210 $dm^3$ syngas/t rice husk<br>530 $dm^3$ py-oil/t rice husk | 120 kW/t rice husk |
| 3 | 0.36 t biochar/t rice husk<br>640 $dm^3$ syngas/t rice husk | 90 kW/t rice husk |

- Material and operating units…

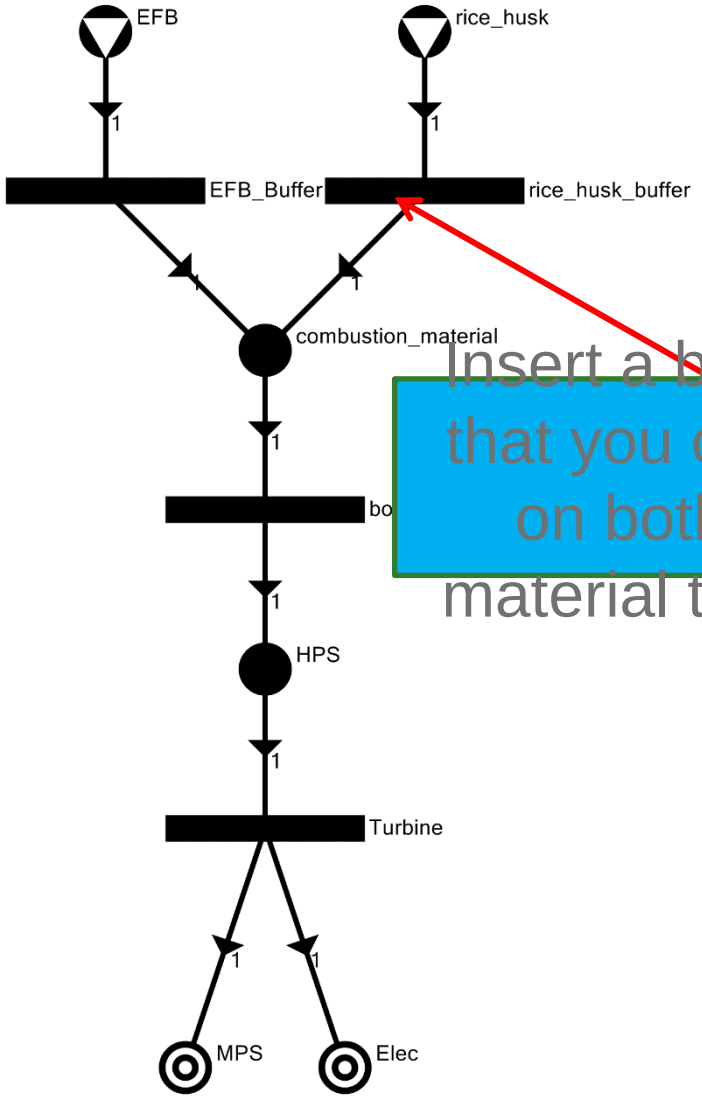
| Material | Price |
|---|---|
| Electricity | Importing price: $0.14 /kW<br>Exporting price: $0.11/kW |
| Bio-char | $350/t |
| Syngas | $0.122/dm$^3$ |
| Py-oil | $0.25/dm$^3$ |

| Op. Unit | Operating Cost | Capital Cost |
|---|---|---|
| Boiler | -- | $ 12.44/t rice husk |
| Turbine | -- | $ 0.03/t HP Steam |
| Fast.p | $14.38/t rice husk | $157.5/ t rice husk |
| Slow.p | $4.45/t rice husk | $95.8/t rice husk |

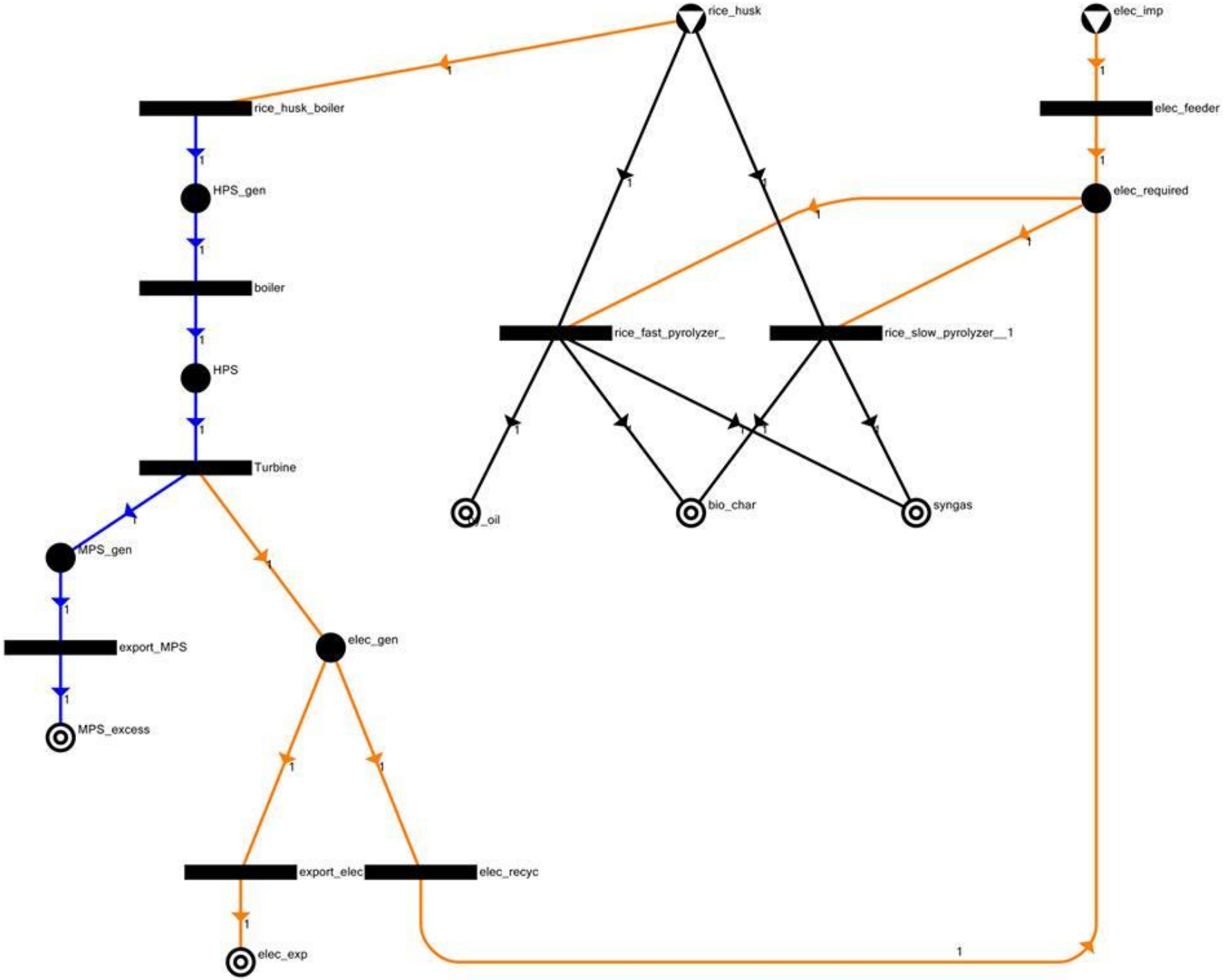
- Generate your MSG in PNS draw now!
- Convert it to PNS file and key in the info
- Answer the questions:
  1. How many possible solutions?
  2. List out the best and 2nd best solutions
  3. Set a capacity constraint of 20 t for slow pyrolyzer, how does it affect your solutions?
  4. If the demand of py-oil is 20 $dm^3$, how does it affect your answer?
  5. Now add another new raw material (bagasse), it can be sent to boiler+turbine , try to reconstruct the MSG in PNS Draw (no need do in PNS studio)




Mixing ratio is not important for this case!




Insert a buffer so that you can add on both raw material together


rice_husk
elec_imp
rice_husk_boiler
elec_feeder
HPS_gen
elec_required
boiler
rice_fast_pyrolyzer_
rice_slow_pyrolyzer__1
HPS
Turbine
bio_char
syngas
MPS_gen
export_MPS
elec_gen
MPS_excess
export_elec
elec_recyc
elec_exp
1

# Thank you for your attention

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