GHG Footprint Reduction Through Carbon Integration

(and some more information)

Patrick Linke

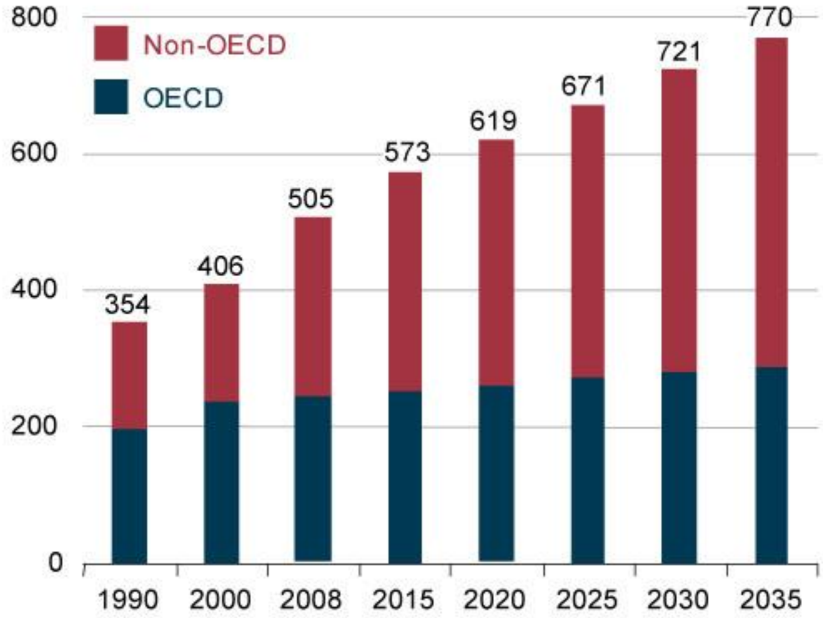
Professor and Chemical Engineering Program Chair

Doha, 16 February 2015

GLOBAL CHANGE:
ENERGY & ENVIRONMENT IN HARMONY ?

Energy

Figure 1. World energy consumption, 1990-2035
(quadrillion Btu)



Environment

- Climate:
  Drastically cut global GHG emissions or else face "Dangerous Climate Change"
- Water:
  1.8 billion people will suffer scarcity by 2025
- Food:
  Mounting pressures on food security
- Local & regional environments:
  Unsustainable footprints in emerging markets (e.g. contamination of air, water & land in Far East, air quality in GCC, …)

Sources: EIA, UN, IPCC

OPPOSING TRENDS

Increasing Demands

Growing Population

Growing Income

Increasing Materials & Energy Intensity

Environment in Decline

Water Scarcity

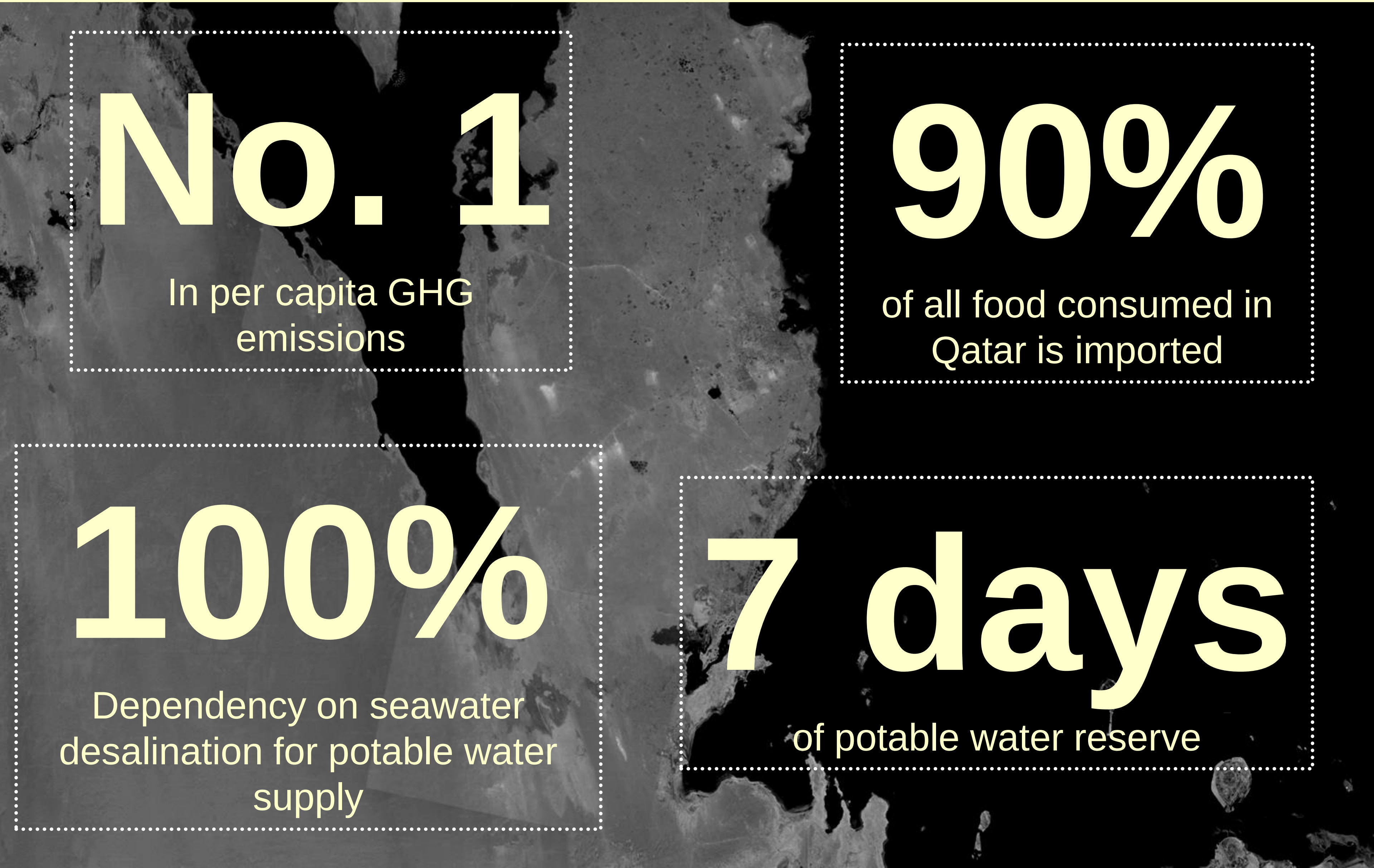
Soil Exhaustion

Climate Change

…

In future we will need to achieve much more with much less !

Local Challenges – Qatar



No. 1

In per capita GHG emissions

90%

of all food consumed in Qatar is imported

100%

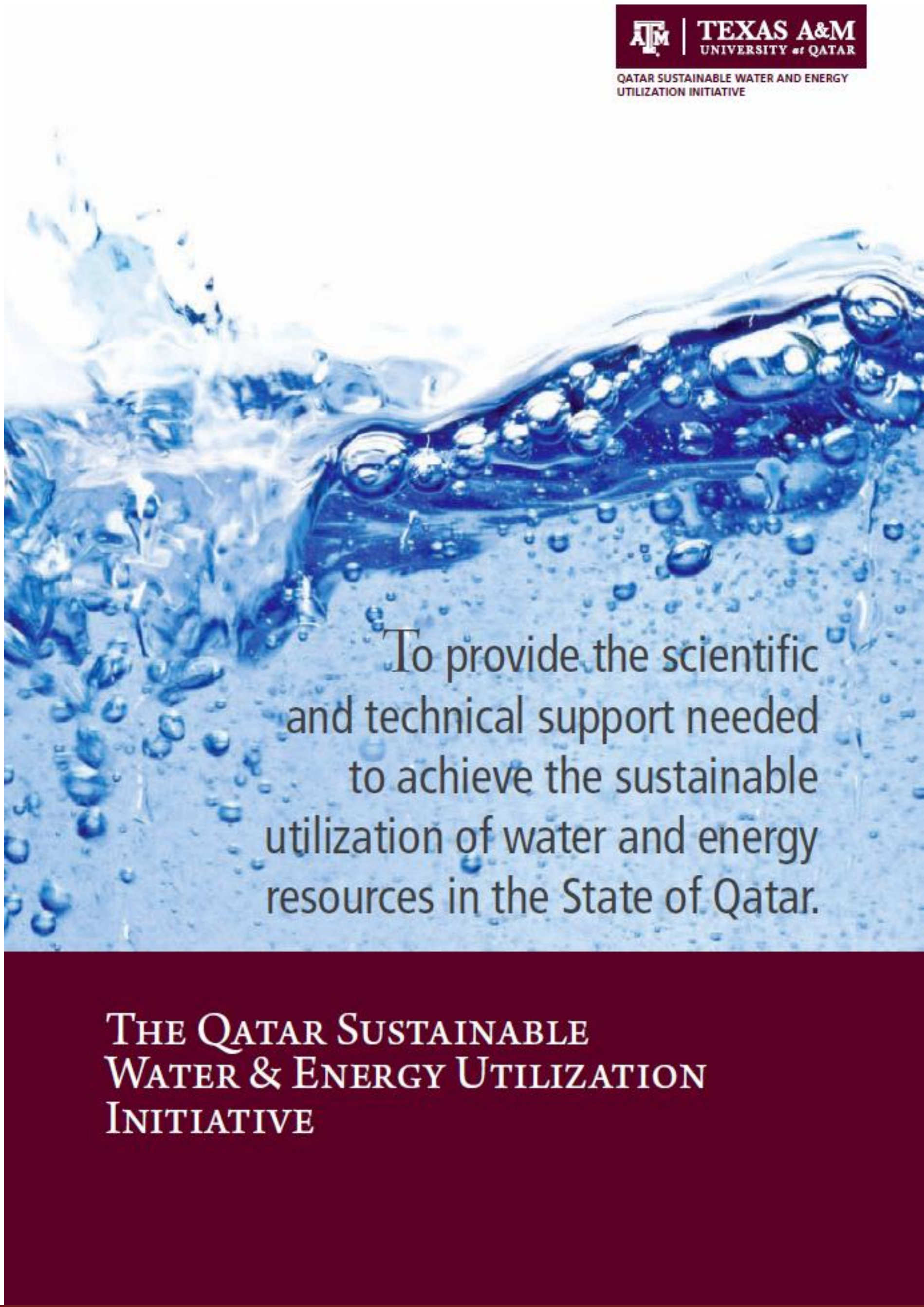
Dependency on seawater desalination for potable water supply

7 days

of potable water reserve

TEES Qatar Sustainable Water & Energy Utilization Initiative (QWE)

Directors:
Patrick Linke, Ahmed Abdel-Wahab



Current Research Activities

- **Advanced water and wastewater treatment processes**
  - Advanced reduction processes
  - Advanced oxidation processes
  - Electrochemical and photo-electrochemical treatment processes
- **Environmental impact assessment and management**
  - Marine discharges
  - Air quality
  - Regulatory revisions and recommendations of new standards
- **Desalination Process Innovation**
  - Zero liquid discharge systems (ZLD)
  - Hybrid desalination systems
  - Desalination pretreatment
- **Utilizing solar energy for carbon dioxide reduction and water treatment**
  - Photo-electrochemical processes for CO_2 conversion to useful fuels
  - Photo-electrochemical water and wastewater treatment processes

Current Research Activities (cont.)

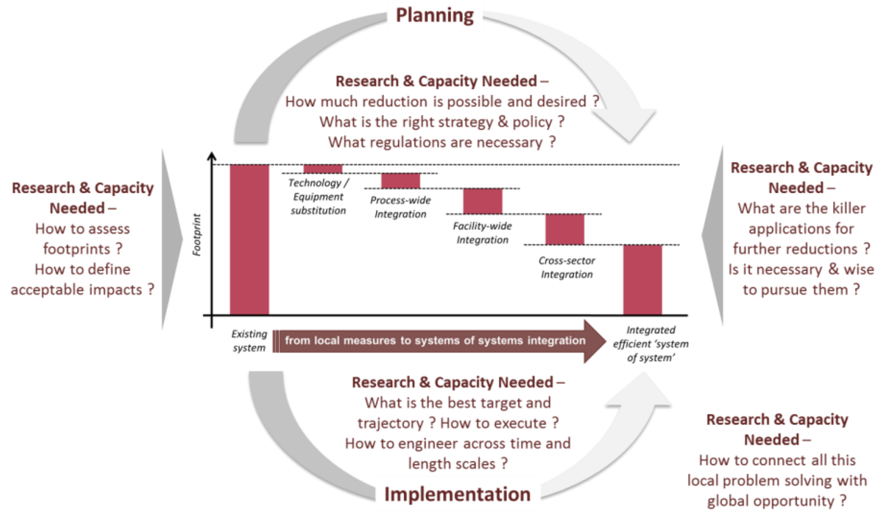
- **Heat to Power Technologies**
  - Organic Rankine Cycles
- **Industrial Energy Systems**
  - Energy integration in industrial cities
  - Renewable energy / systems integration
- **Integrated water resources management**
  - Macroscopic water systems design and optimization
- **Water-Energy Nexus and Eco-Industrial Parks**
  - Integrated water-Energy Systems
  - Industrial ecologies around wastes and by-products, CO_2 integration

Research & outreach

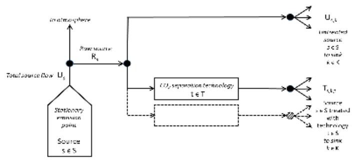
EXAMPLES OF ONGOING RESEARCH

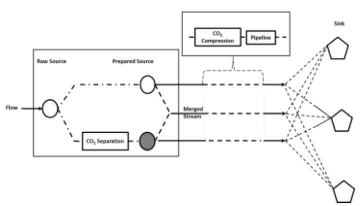
Design Approaches for Sustainable Industrial Systems

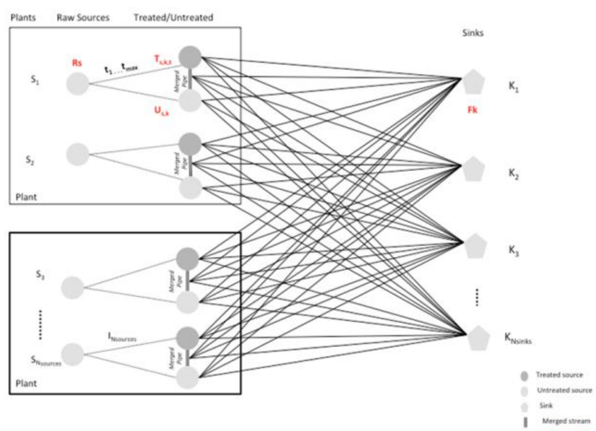
Systematic minimization of footprints

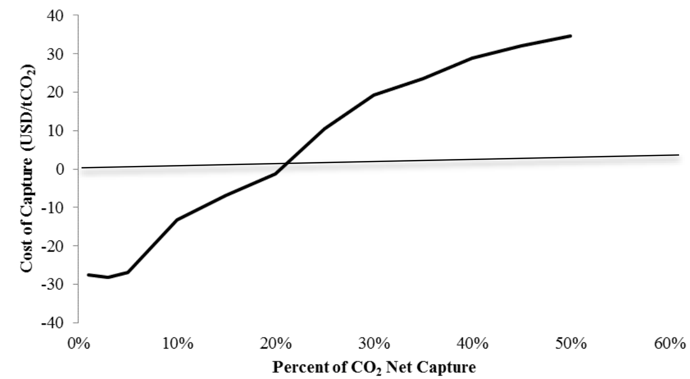


Network synthesis, multi-period planning, simultaneous nexus integration









Design Approaches for Sustainable Industrial Systems

Energy 36 (2011) 4019–4031
Contents lists available at ScienceDirect
Energy
journal homepage: www.elsevier.com/locate/energy

Optimal waste heat recovery and reuse in industrial zones

Mirko Z. Stijepovic, Patrick Linke*
Department of Chemical Engineering, Texas A&M University at Qatar, Education City PO Box 23874, Doha, Qatar

Energy 47 (2012) 302–313
Contents lists available at SciVerse ScienceDirect
Energy
journal homepage: www.elsevier.com/locate/energy

Targeting and design of industrial zone waste heat reuse for combined heat and power generation

Vladimir Z. Stijepovic[b], Patrick Linke[a,*], Mirko Z. Stijepovic[a], Mirjana Lj. Kijevčanin[b],

I&EC research
Industrial & Engineering Chemistry Research
Article
pubs.acs.org/IECR

Multiperiod Planning of Optimal Industrial City Direct Water Reuse Networks

Sumit Kr. Bishnu,[†] Patrick Linke,[*,†] Sabla Y. Alnouri,[†] and Mahmoud El-Halwagi[‡]
[†]Department of Chemical Engineering, Texas A&M University at Qatar, P.O. Box 23874, Education City, Doha, Qatar
[‡]The Artie McFerrin Department of Chemical Engineering, Texas A&M University, College Station, Texas 77843-3122, United States

AIChE

Optimal Interplant Water Networks for Industrial Zones: Addressing Interconnectivity Options Through Pipeline Merging

Sabla Y. Alnouri
Dept. of Chemical Engineering, Texas A&M University at Qatar, P.O Box 23874, Education City, Doha, Qatar
The Artie McFerrin Dept. of Chemical Engineering, Texas A&M University, College Station, TX
Patrick Linke
Dept. of Chemical Engineering, Texas A&M University at Qatar, P.O Box 23874, Education City, Doha, Qatar

Journal of Cleaner Production 89 (2015) 231–250
Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro

A synthesis approach for industrial city water reuse networks considering central and distributed treatment systems

Sabla Y. Alnouri[a,b], Patrick Linke[a,*], Mahmoud El-Halwagi[b]

ACS Sustainable Chemistry & Engineering
Research Article
pubs.acs.org/journal/ascecg

Water and Energy Issues in Gas-to-Liquid Processes: Assessment and Integration of Different Gas-Reforming Alternatives

Diana Yered Martínez,[†] Arturo Jiménez-Gutiérrez,[*,†] Patrick Linke,[‡] Kerron J. Gabriel,[§] Mohamed M. B. Noureldin,[§] and Mahmoud M. El-Halwagi[§,∥]

Now moving across nexus and widening scope for carbon dioxide management.

Innovating Organic Rankine Cycles

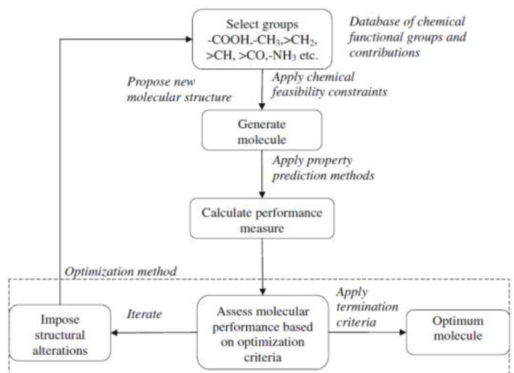
Solar

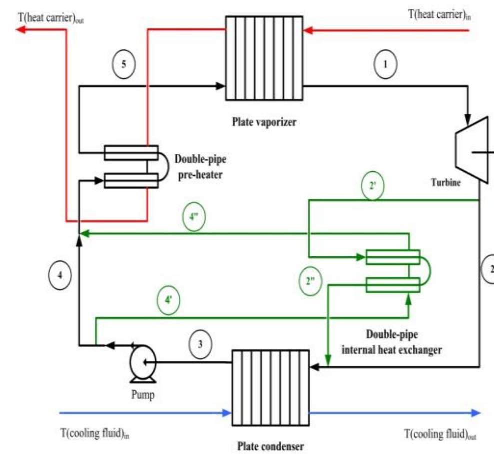
Waste heat

Biomass

Geothermal

Computer-Aided Molecular Design
+
High-performance Cycle Design & Optimization





Innovating Organic Rankine Cycles

Applied Thermal Engineering 30 (2010) 760–769

Contents lists available at ScienceDirect

ELSEVIER

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

On the systematic design and selection of optimal working fluids for Organic Rankine Cycles

Athanasios I. Papadopoulos [a,b], Mirko Stijepovic [c], Patrick Linke [c,*]

I&EC research

Industrial & Engineering Chemistry Research

Article

pubs.acs.org/IECR

Toward Optimum Working Fluid Mixtures for Organic Rankine Cycles using Molecular Design and Sensitivity Analysis

Athanasios I. Papadopoulos,[*,†] Mirko Stijepovic,[‡] Patrick Linke,[‡] Panos Seferlis,[§] and Spyros Voutetakis[†]

Applied Thermal Engineering 75 (2015) 384–396

Contents lists available at ScienceDirect

ELSEVIER

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Novel and conventional working fluid mixtures for solar Rankine cycles: Performance assessment and multi-criteria selection

CrossMark

Paschalia Mavrou [a,b], Athanasios I. Papadopoulos [a,*], Mirko Z. Stijepovic [c], Panos Seferlis [a,b], Patrick Linke [c], Spyros Voutetakis [a]

Applied Thermal Engineering 36 (2012) 406–413

Contents lists available at SciVerse ScienceDirect

ELSEVIER

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

On the role of working fluid properties in Organic Rankine Cycle performance

Mirko Z. Stijepovic [a], Patrick Linke [a,*], Athanasios I. Papadopoulos [b], Aleksandar S. Grujic [c]

Energy xxx (2014) 1–14

Contents lists available at ScienceDirect

ELSEVIER

Energy

journal homepage: www.elsevier.com/locate/energy

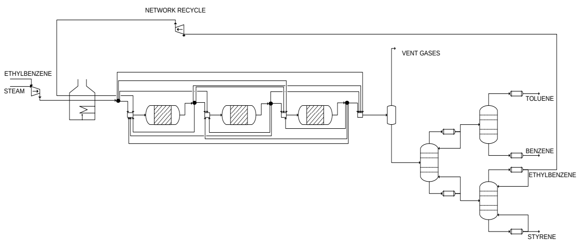
An exergy composite curves approach for the design of optimum multi-pressure organic Rankine cycle processes

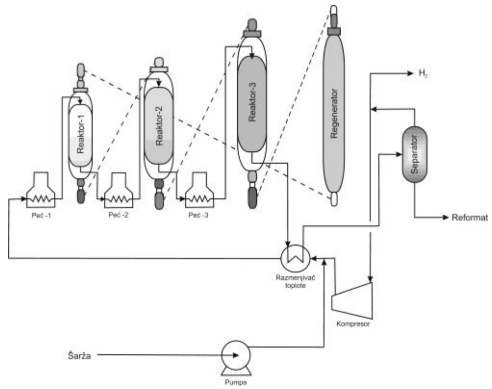
Mirko Z. Stijepovic [a,*], Athanasios I. Papadopoulos [b], Patrick Linke [a], Aleksandar S. Grujic [c], Panos Seferlis [d]

CAMD for WF selection: Pure components & mixtures, Optimal Cycle design & integration, Property-performance relationships, Design & selection for dynamic performance

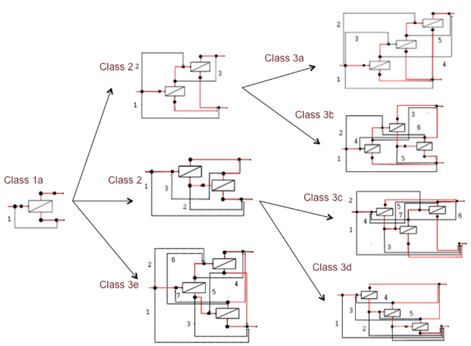
Approaches to Process Design and Optimization

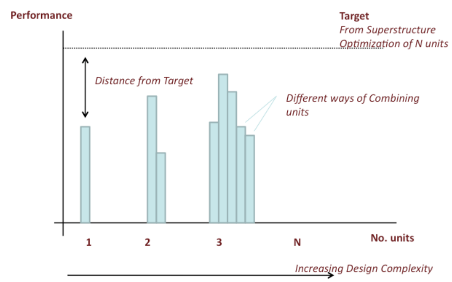
Optimization frameworks and tools for the systematic innovation of processes





Het. catalytic conversions





Desalination processes

Chemical Engineering Journal 163 (2010) 438–449

Contents lists available at ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Optimal conceptual design of processes with heterogeneous catalytic reactors

Daniel Montolio-Rodriguez[a], Patrick Linke[a,b,*], David Linke[c], Mirko Z. Stijepovic[b]

[a] Center for Process & Information Systems Engineering, University of Surrey, Guildford, Surrey GU2 7XH, UK

Energy Fuels 2010, 24, 1908–1916 · DOI:10.1021/ef901193v
Published on Web 01/14/2010

energy&fuels article

Optimization Approach for Continuous Catalytic Regenerative Reformer Processes

Mirko Z. Stijepovic,*,† Patrick Linke,† and Mirjana Kijevcanin‡

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 37 (2012) 11772–11784

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/he

Toward enhanced hydrogen production in a catalytic naphtha reforming process

Vladimir Stijepovic[a], Patrick Linke[b], Sabla Alnouri[b], Mirjana Kijevcanin[a],

Journal of Membrane Science 417–418 (2012) 96–112

Contents lists available at SciVerse ScienceDirect

Journal of Membrane Science

journal homepage: www.elsevier.com/locate/memsci

A systematic approach to optimal membrane network synthesis for seawater desalination

Sabla Y. Alnouri, Patrick Linke*

Desalination 345 (2014) 112–127

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Optimal seawater reverse osmosis network design considering product water boron specifications

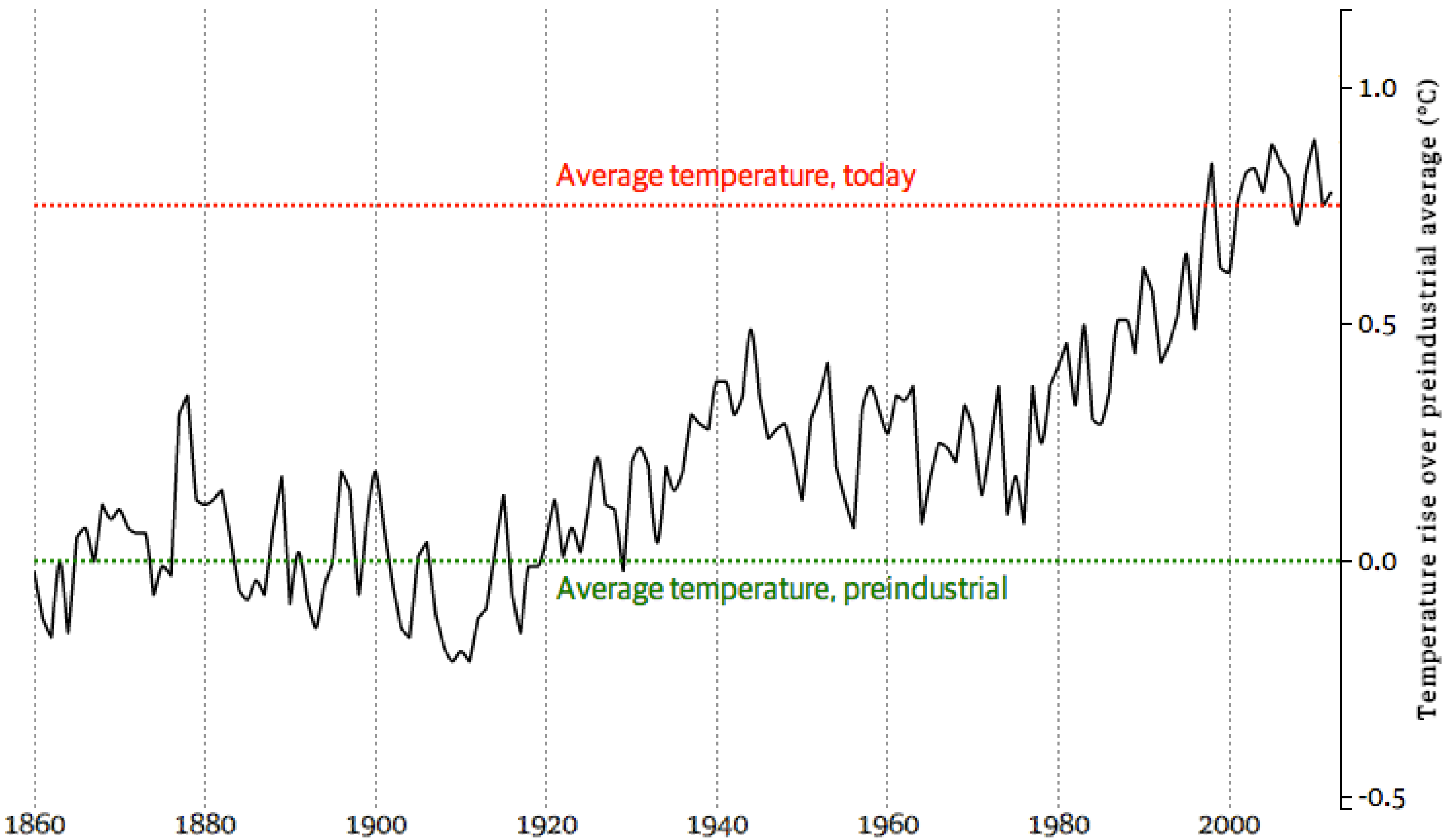
Sabla Y. Alnouri, Patrick Linke*

Department of Chemical Engineering, Texas A&M University at Qatar, PO Box 23874, Education City, Doha, Qatar

Grad students: Dhabia Al-Mohannadi, Sumit Binshu, Sabla Alnouri

GHG FOOTPRINT REDUCTION THROUGH CARBON INTEGRATION

"Unequivocal" Increase – IPCC, 2014
"Wake-Up Call" – John Kerry, US Secretary of State, 2014




Bangladesh
2009


Pakistan
2010


Tuvalu
2009

60%

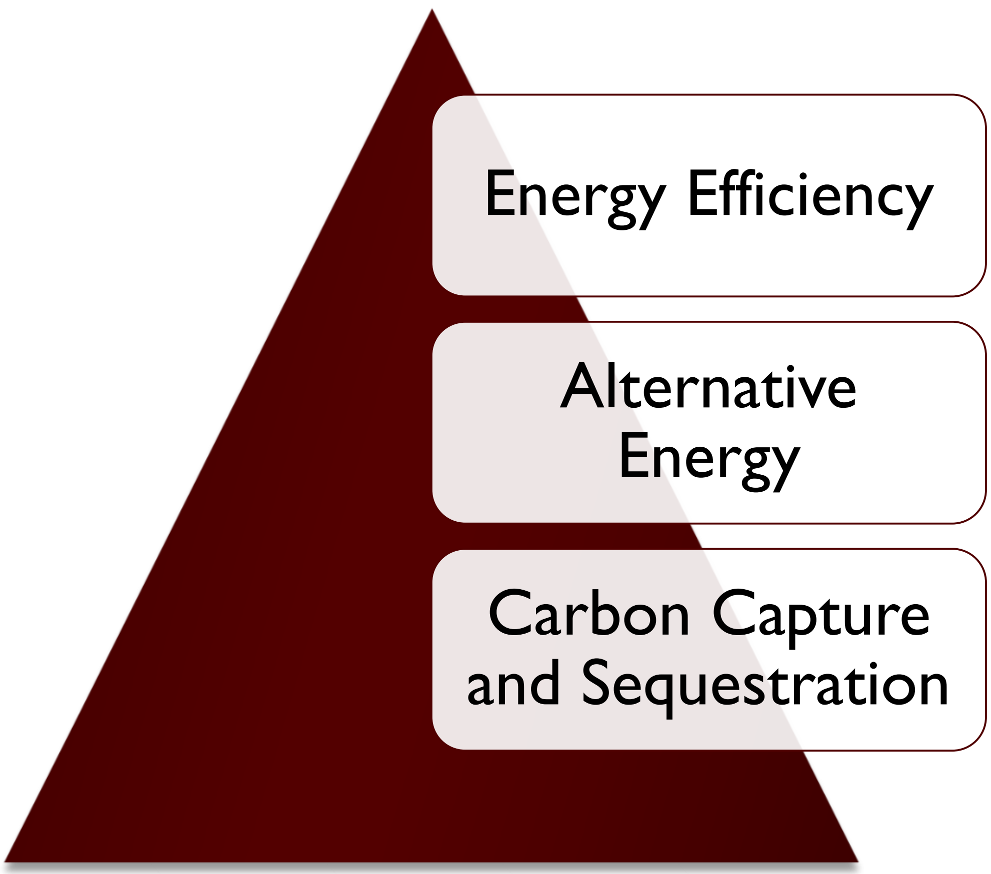
Global target for emission reduction by 2050
required to keep below 2°C increase
- Presidential Climate Action Project

80%

Industrial countries target for emission reduction by 2050 required to keep below 2°C increase
- Presidential Climate Action Project

What possibilities exist to reduce industrial carbon footprints ?

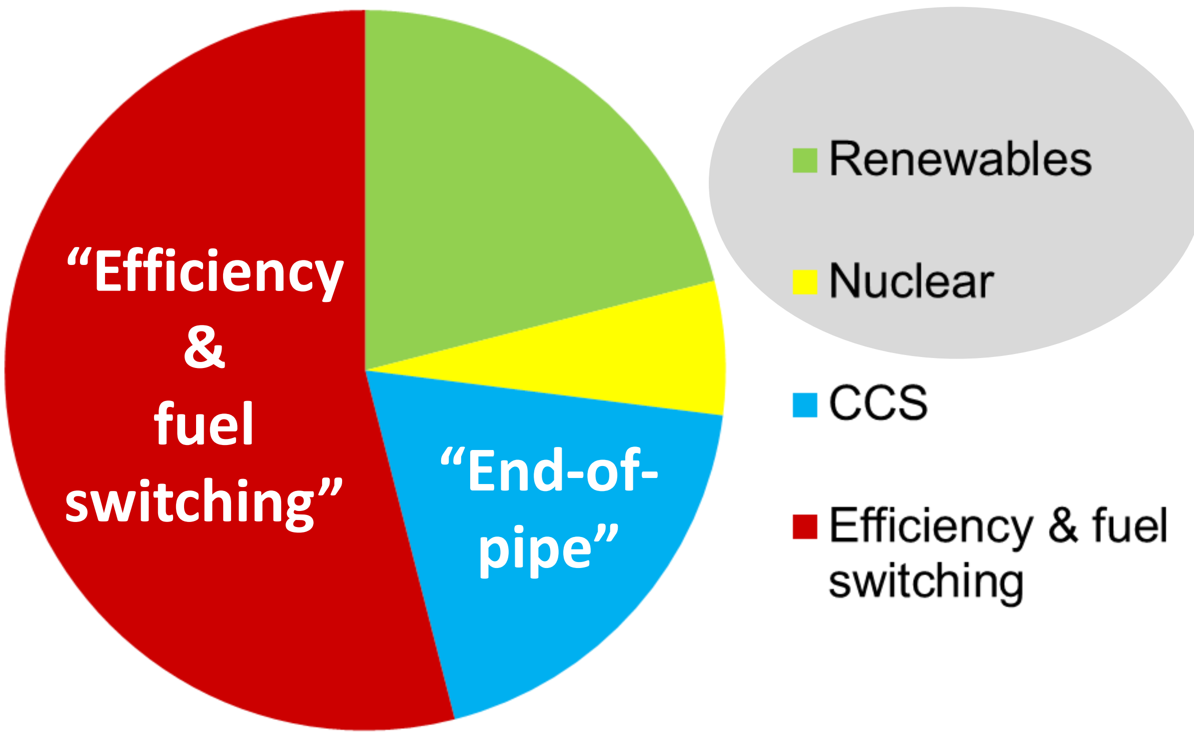
Common approaches to industrial carbon footprint reduction



- Reduction of CO2 produced as a result of fuel use
  - Reduction of amount of fuel through enhanced energy efficiency
  - Fuel switching
  - Renewables
- Capture of produced CO2
  - Can be geological/biological
  - Involves removal of CO2 using a capture unit, delivery and injection into sites

NATURAL GAS & EFFICIENCY – IMPORTANT KEYS TO AN INTERMEDIATE LOW CARBON FUTURE

IEA: Avoiding dangerous Climate Change through abatement of energy-related CO_2 over business as usual scenarios



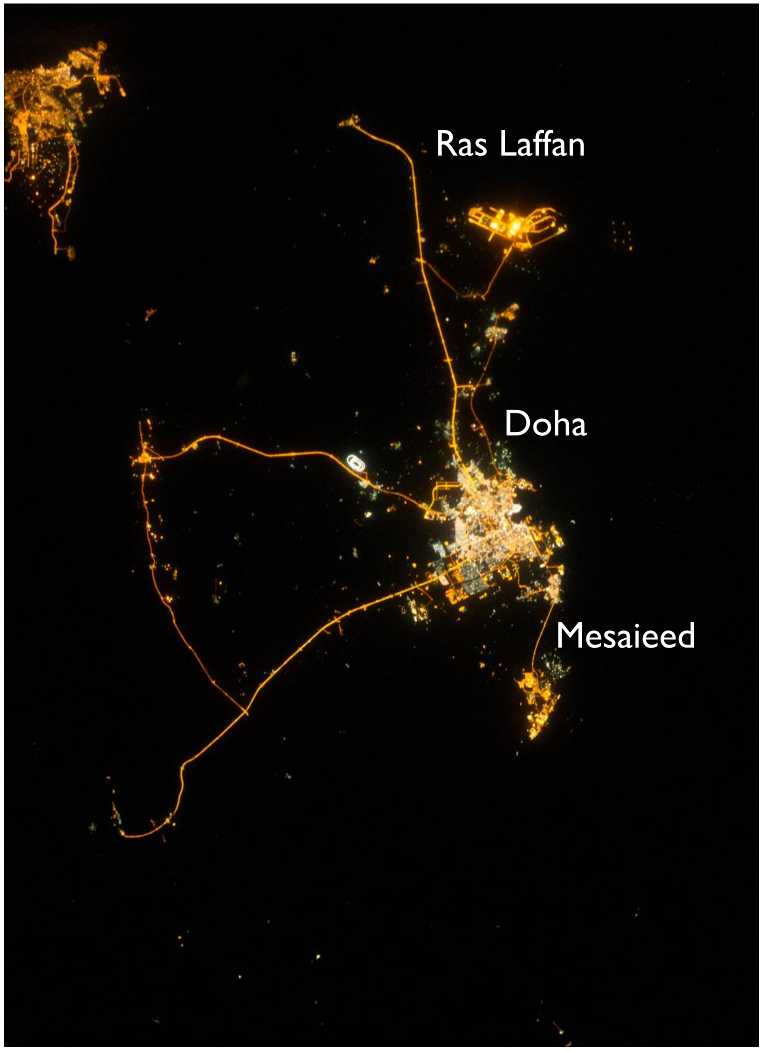
"Alternative energy" – *only one part of the answer.*

Example: 450ppm scenario by 2050

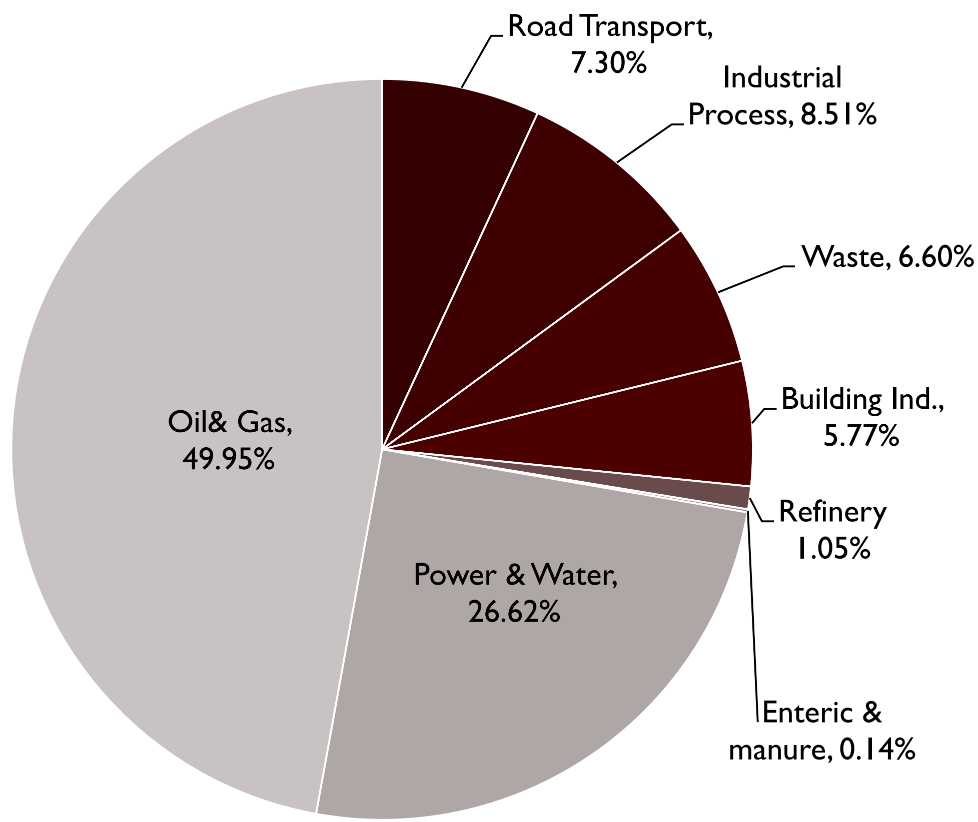
(IEA, Energy Technology Perspectives, 2008)

Global problems vs. local impacts

Main CO_2 Emission Sources

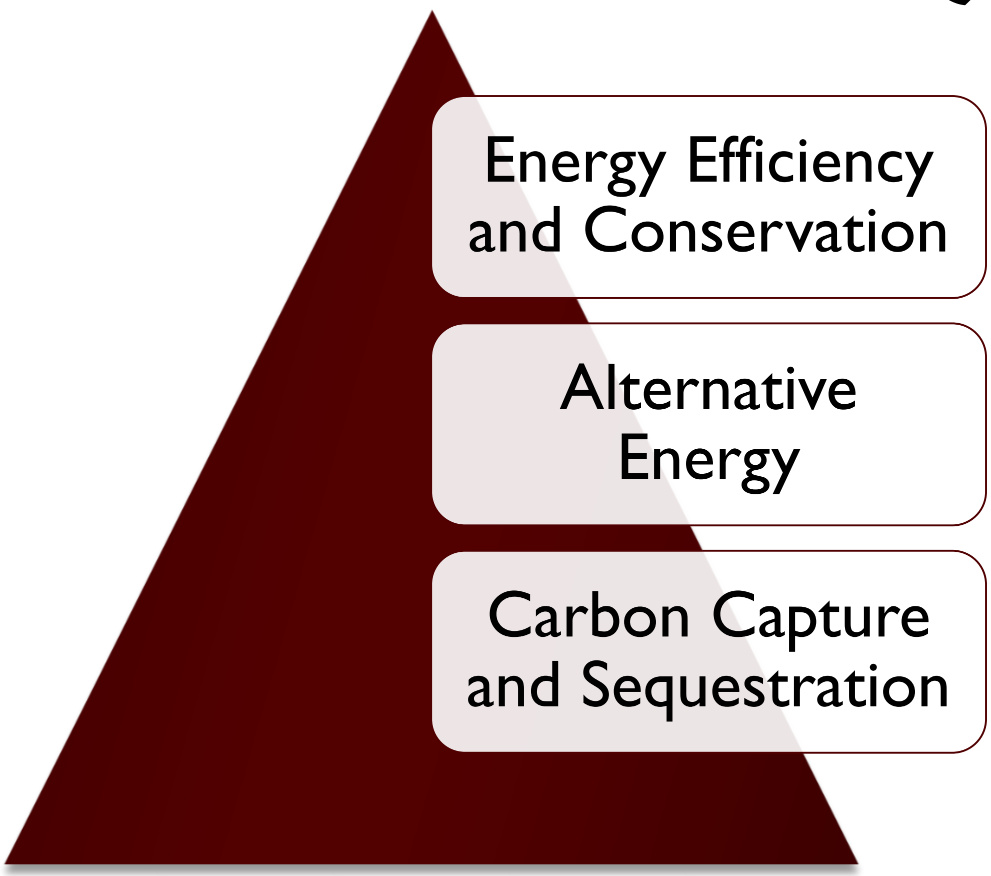


- Qatar



EIA: Qatar's main emissions; 2011

Popular CO_2 Reduction Methods

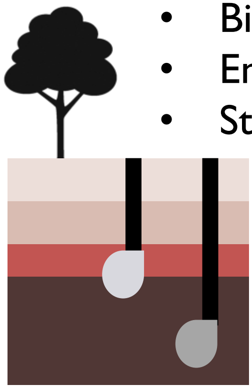


- Qatar
  - Tarsheed National Program
  - Most processing plants e.g.
    - LNG facilities
    - Most recent GTL technologies
  - Qatar Solar Technologies
  - QSTP- Algal Biofuels
  - Qatar 2022 carbon neutral stadium
  - Green Gulf Solar Test Facility
  - Kahramaa; 220 MW solar plant
  - QP-QSTP Imperial College of London
  - QAFAC Methanol CO_2 Recovery plant

Industrial City Emissions Reduction Options

CCS

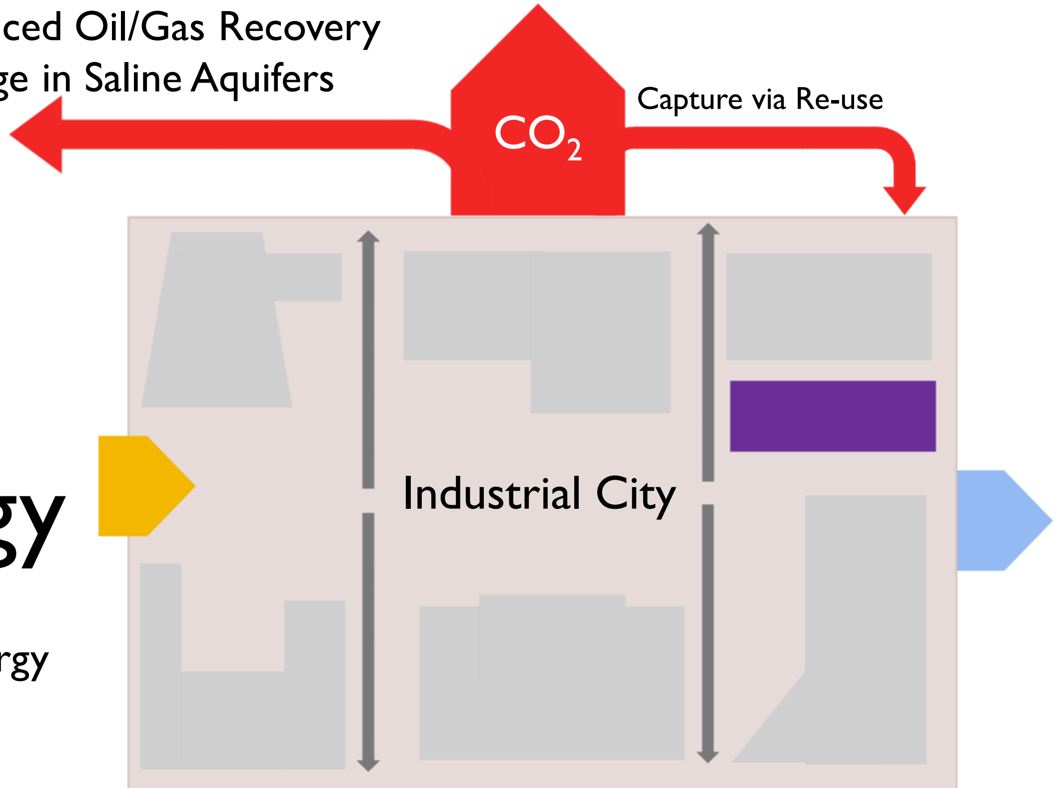
- Biofixation
- Enhanced Oil/Gas Recovery
- Storage in Saline Aquifers



Utilization

&

Symbiosis ?



Energy

Fossil fuels

Renewable Energy

- Solar
- Wind
- Biofuels

Products

Which products?

Which processes?

Existing or new?

Capacity of fixation?

How will it fit in the layout?

Is it better than CCS?

Processes

- Improve energy efficiency
- Substitute processes and technology

Previous Work – PSE Approaches

- Linhoff 1978
- Smith and Delaby, 1991
- Klemes et al, 1997
- Tan and Foo, 2007
- Pekala et al, 2010
- Al-Mayyahi, 2013
- Ooi et al, 2013

Energy Integration for CO_2 Reduction

Carbon Capture and Sequestration Allocation

- Turk et al, 1987
- Middleton et al, 2009
- Tan et al, 2012
- He et al. 2013
- Hasan et al, 2014
- Alhajaj et al, 2014

- Footprint through energy integration & fuel switching
- Integration of renewable energy sources
- Carbon capture and storage

How to allocate produced carbon dioxide for efficient footprint reduction ?

→ **Carbon Integration**

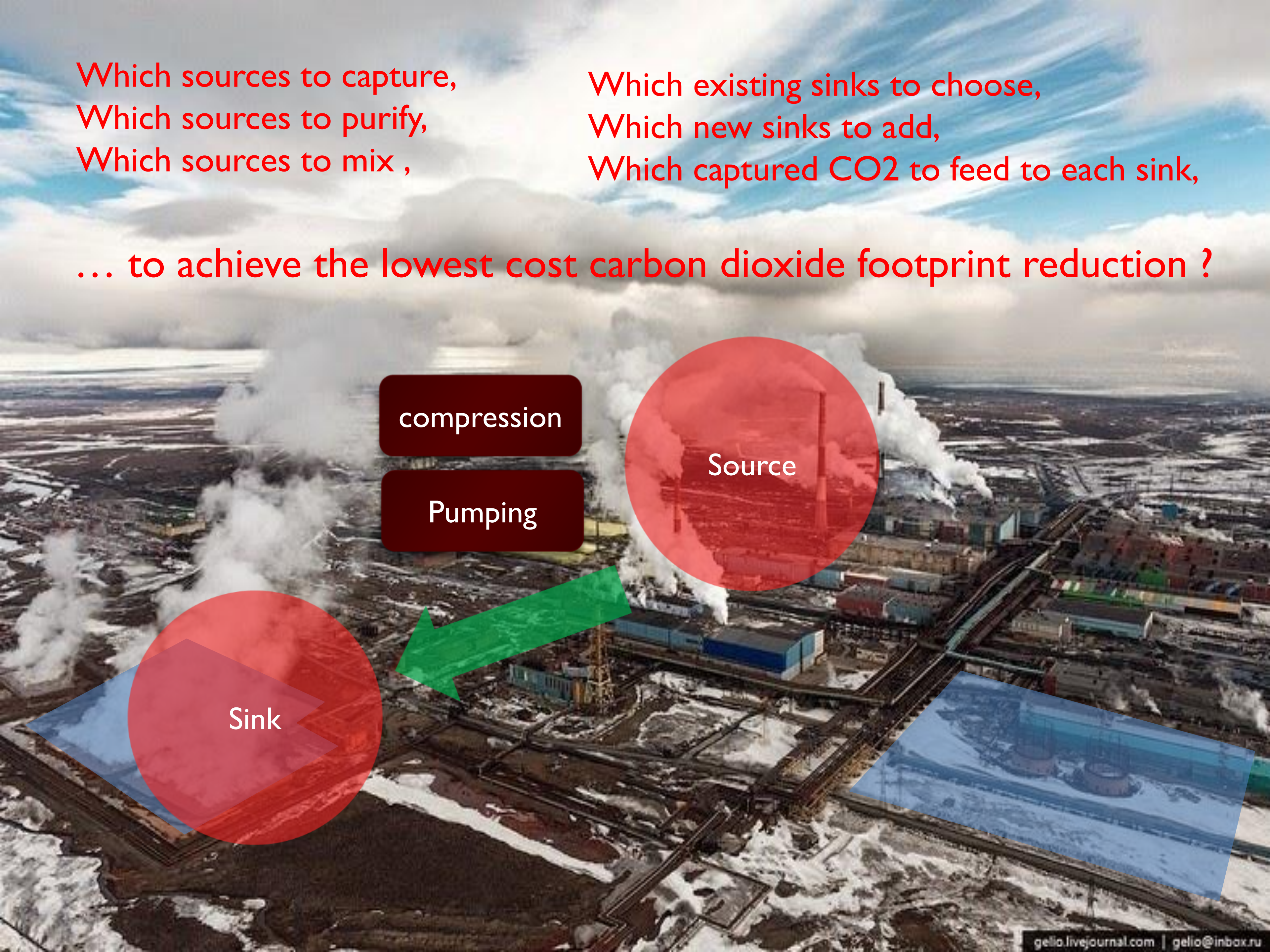
- Multiple Sources Different emission points e.g.
  - Process vents
  - Natural gas reformers
  - Gas turbines
  - Steam boilers

- Possible Sinks
  - Existing
  - Newly added

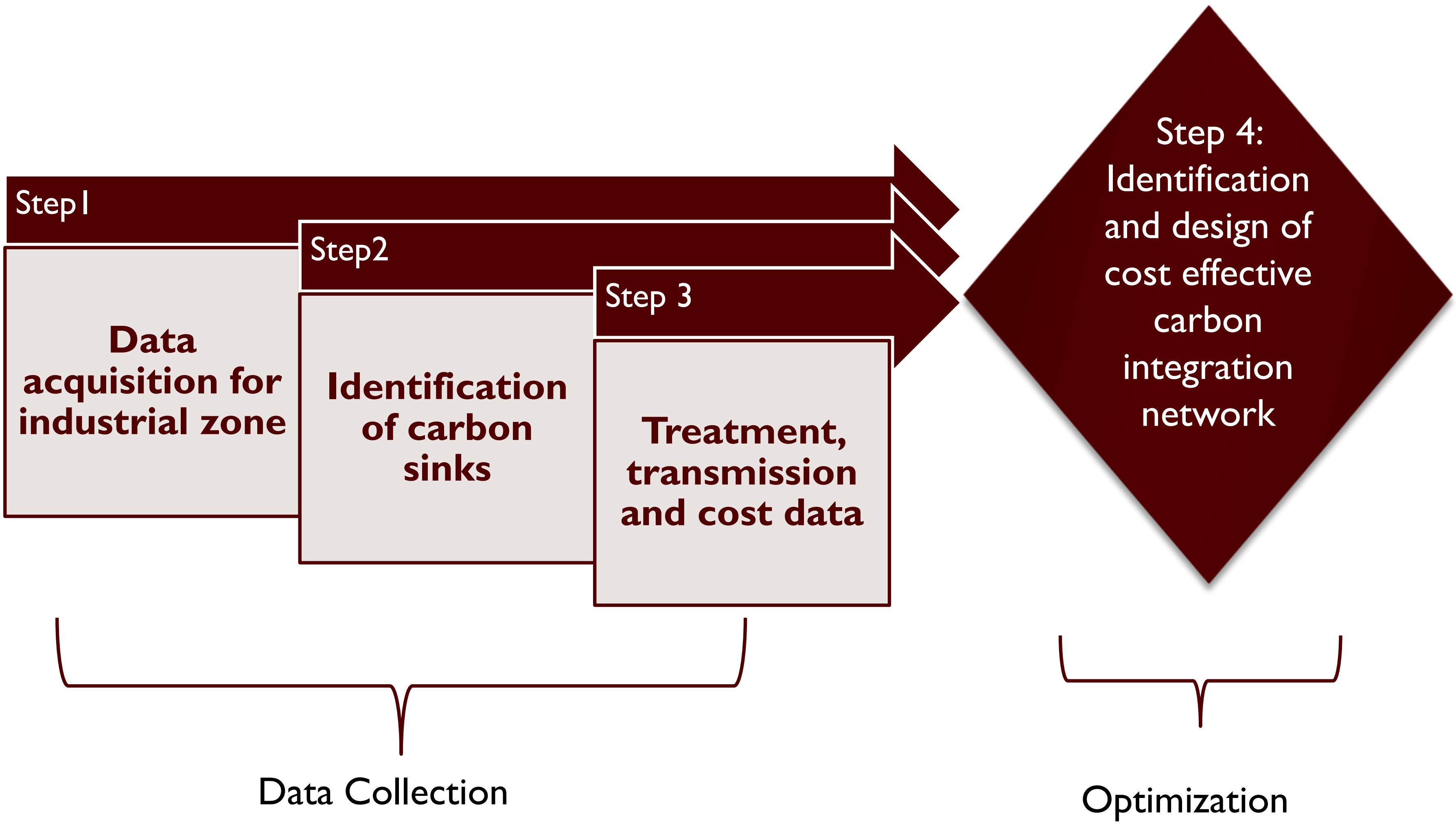
  (to store or convert CO_2)

- Processing
  - Capture
  - Treatment

- Spatial constraints
  - Source & Sink locations
  - Transportation corridors


Which sources to capture,
Which sources to purify,
Which sources to mix ,
Which existing sinks to choose,
Which new sinks to add,
Which captured CO2 to feed to each sink,
… to achieve the lowest cost carbon dioxide footprint reduction ?
compression
Pumping
Source
Sink
gelio.livejournal.com | gelio@inbox.ru

Approach


Step1
Data acquisition for industrial zone
Step2
Identification of carbon sinks
Step 3
Treatment, transmission and cost data
Step 4: Identification and design of cost effective carbon integration network
Data Collection
Optimization

Step 1: Data acquisition for industrial zone

Data about sources

Step 1: Data acquisition for industrial zone

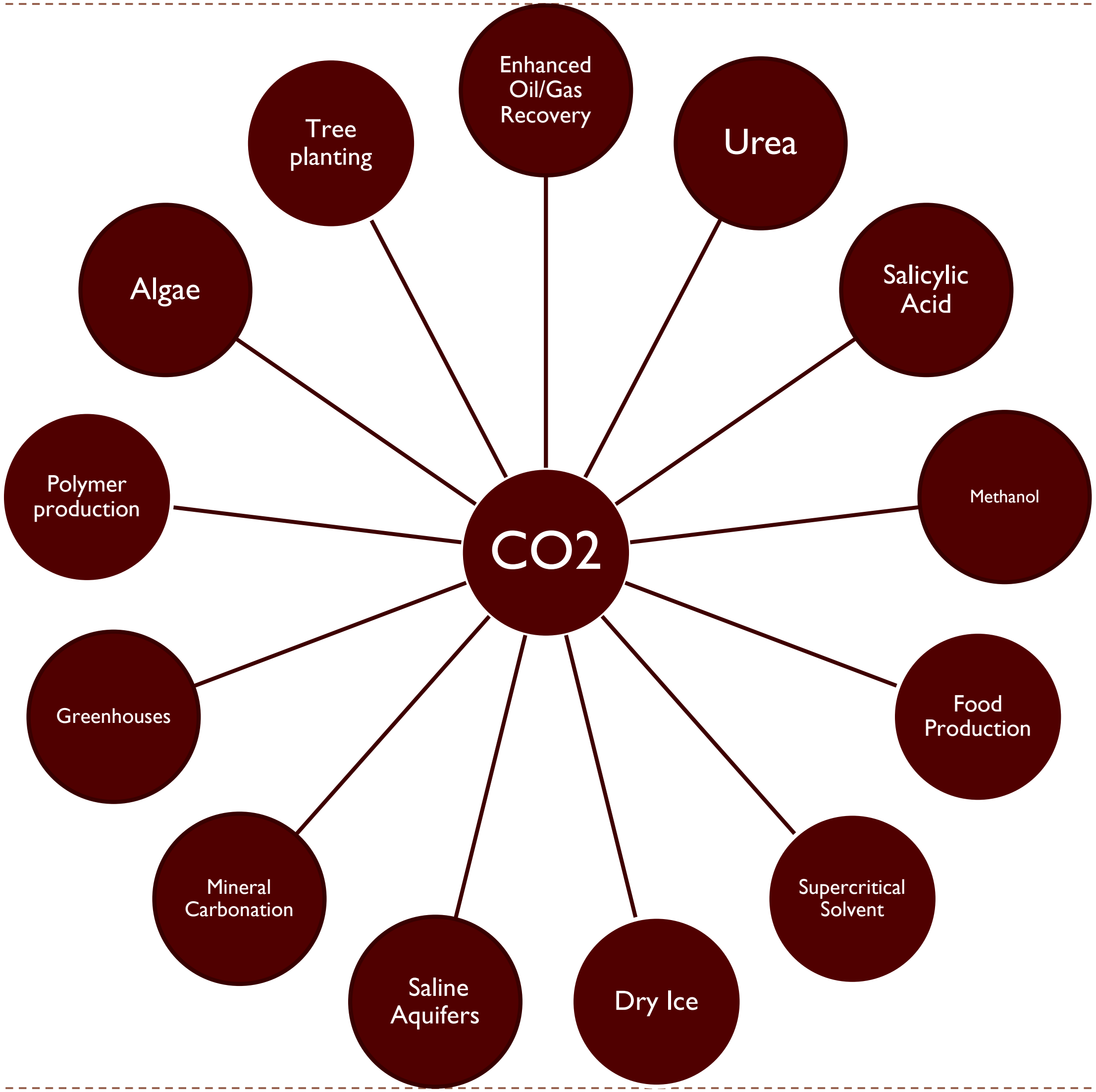
- CO_2 Source Information

Plant	Source	CO_2 Flow	Composition of CO_2	Pressure of stream released	Temperature of stream	Location

- Spatial information (corridors)

Step 2: Identification of carbon sinks

TEXAS A&M UNIVERSITY at QATAR



Usual suspects

+

New emerging options

Possible selection criteria

- Maturity
- Level of fixation
- Potential revenue
- Compatibility with existing system
- Geological availability

Step 2: Identification of carbon sinks

- CO_2 Sink Information

Plant	CO_2 Flow Capacity	Composition of CO_2 Required	Feed Pressure	Cost of CO_2 in sink	Efficiency factor of sink	Location

Step 3: Treatment, transmission and cost data

- Carbon separations
  - Efficiency of carbon removal
  - Cost of capture
- Transmission
  - Relative distances
  - Pipeline costs
  - Compression and pumping costs

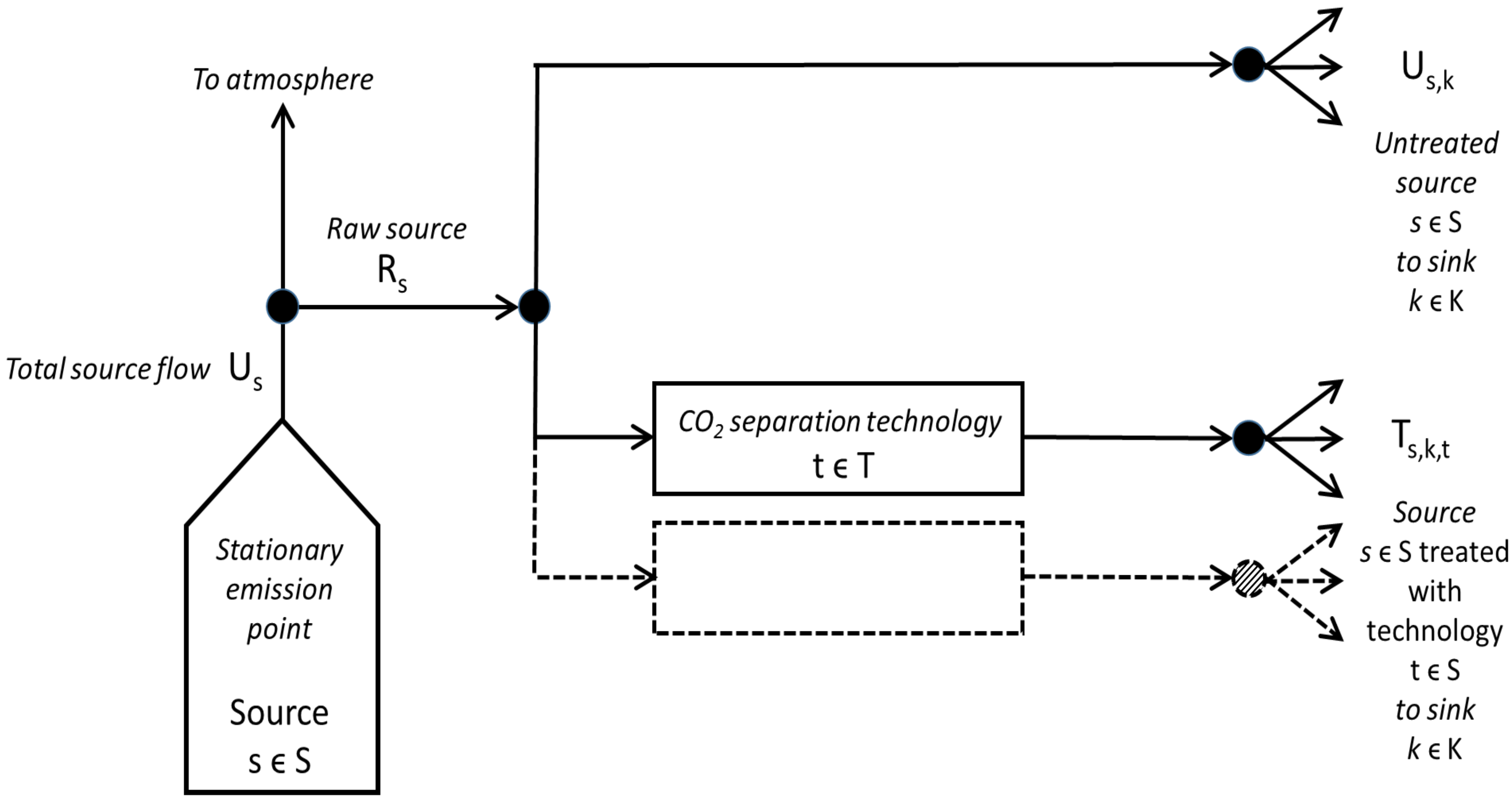
Step 4:Identification and design of cost effective carbon integration network

Problem Statement

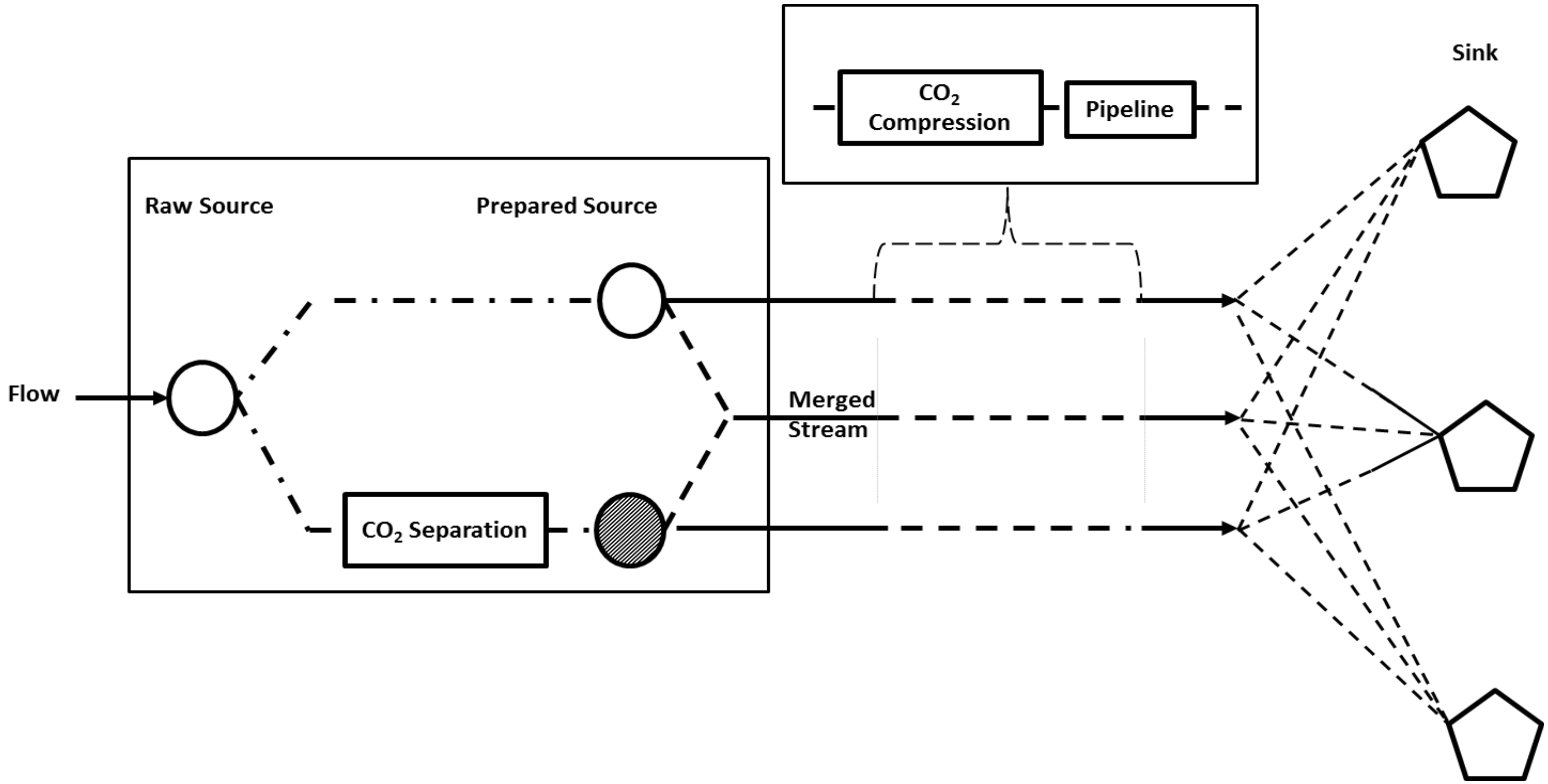
- *Given*
  - An industrial city with a number of plants
  - A number of emission streams (sources) of known flow rate, composition, temperature, pressure
  - A number of existing/potential processes (sinks) that can receive emissions with known CO_2 capacity, purity requirements, temperature, pressure
  - One (or more) carbon separation technology with known performance
  - Distances between all sources and all sinks

- *Determine*
  - The cost-optimal network the connects sources and sinks within the industrial city for a given carbon footprint reduction

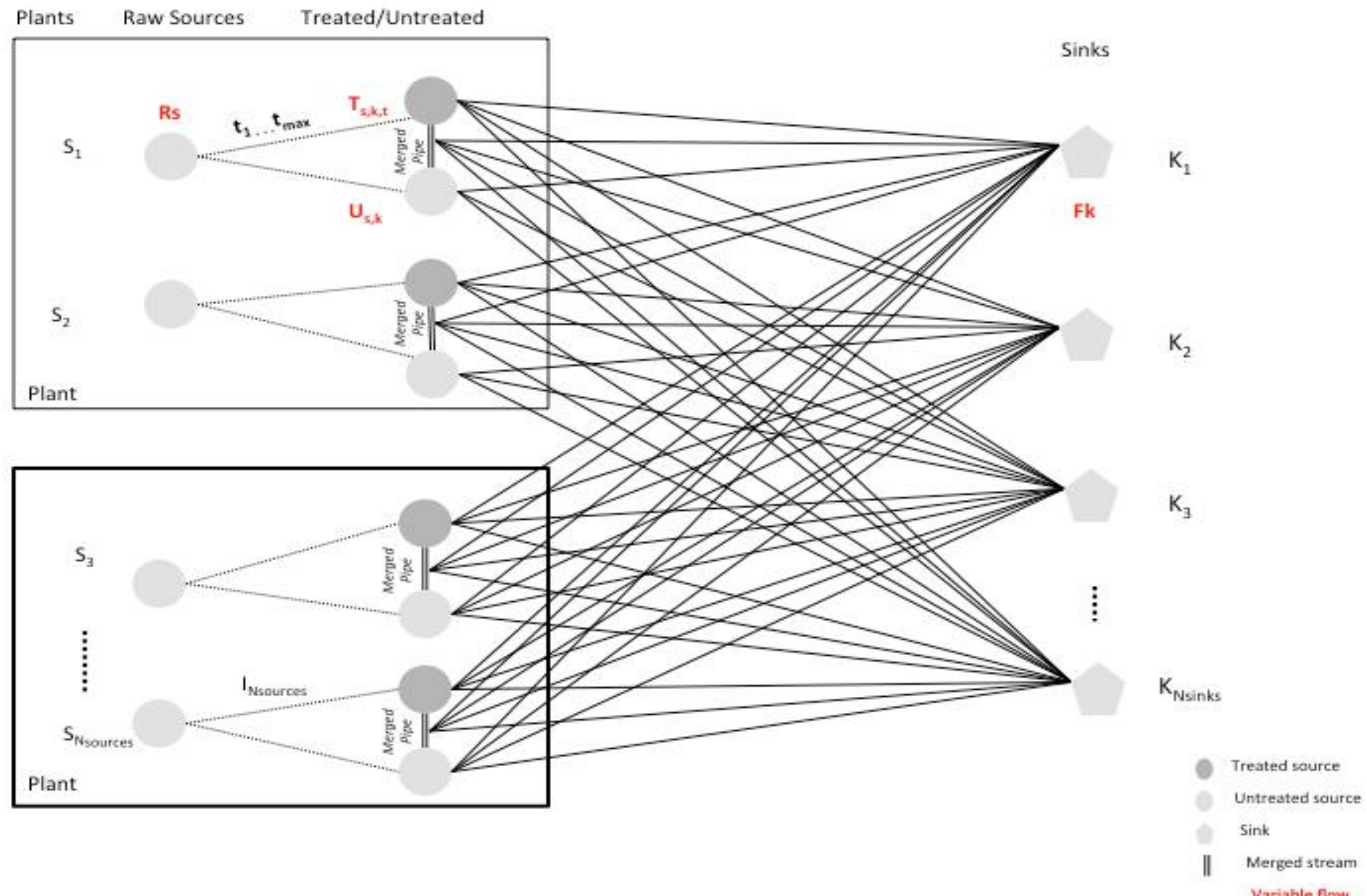
Representation



Representation



Representation



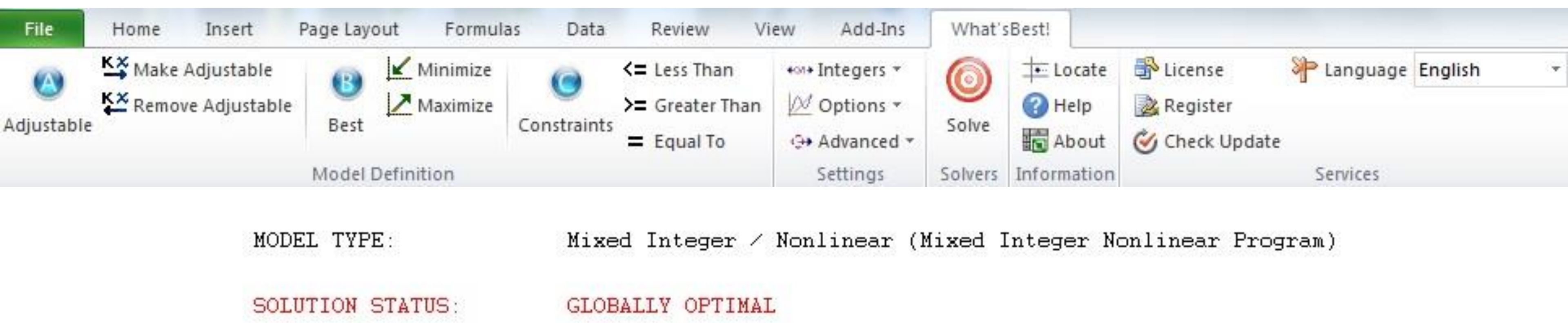
Source to Sink connectivity illustrated for one treatment technology

Optimization problem

- Minimize Total Cost
  - Total Cost = Cost of sinks + Cost of treatment + Cost of compression + Cost of pumping + Cost of pipelines
- Subject to
  - Network mass balances
  - Flow and purity constraints
  - Net capture requirements
- Mixed Integer Non-Linear Program (MINLP)

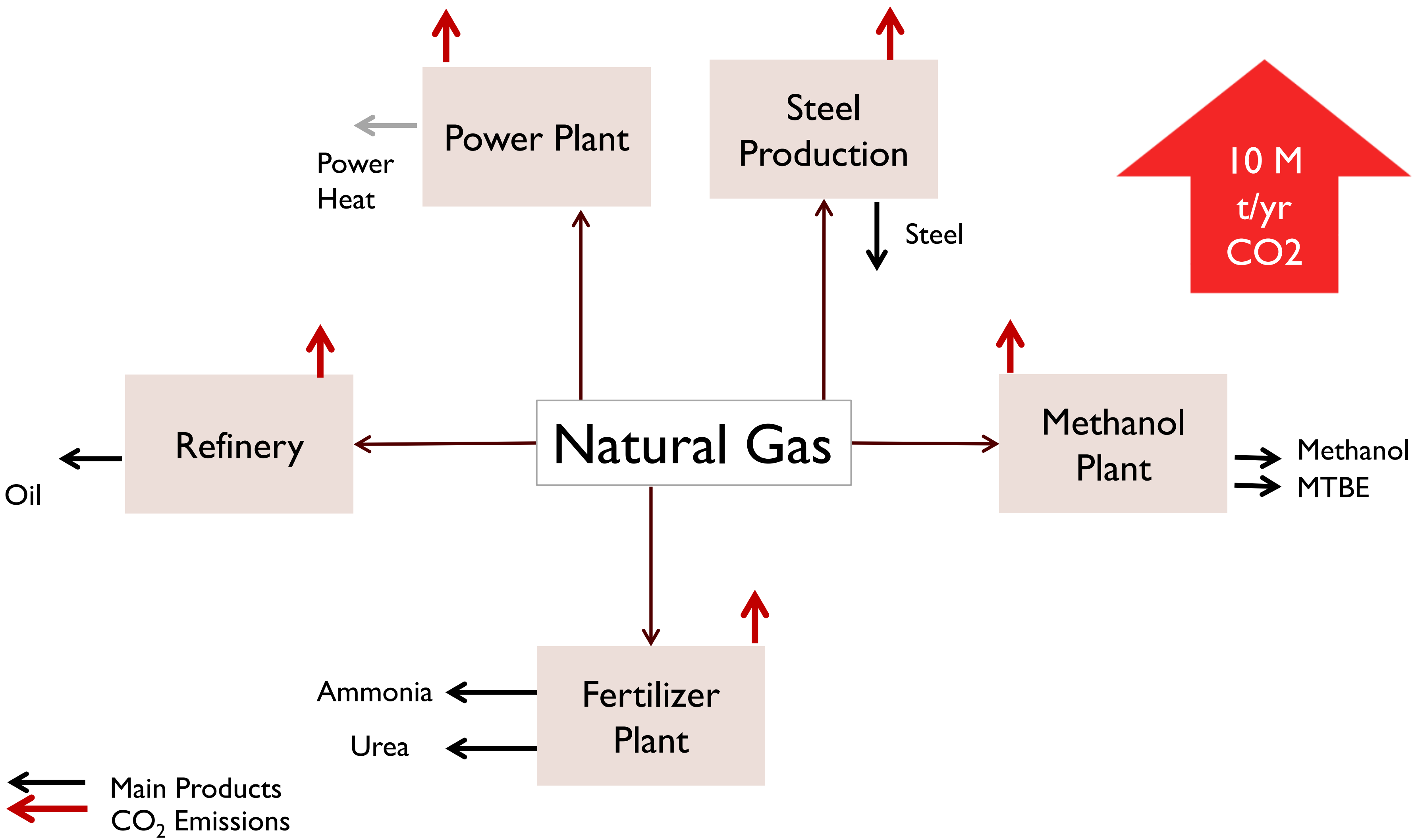
Implementation

- “What’s Best 12.0” Lindo Global solver for MS-Excel 2010 via a laptop with Intel Core i7 Duo processor, 8 GB RAM and a 32-bit operating System.

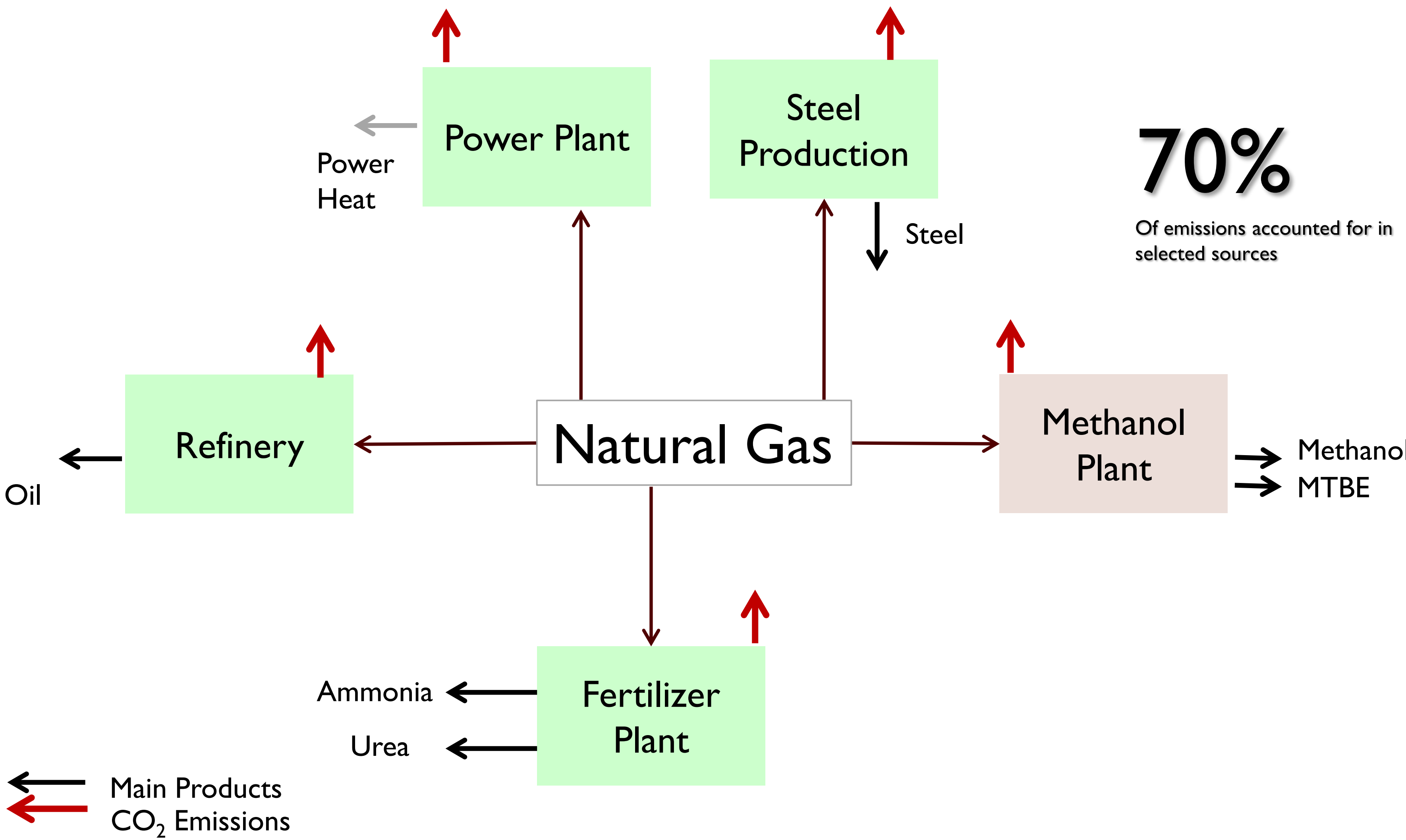


Case Study

System


Power Plant
Power
Heat
Steel
Production
Steel
10 M
t/yr
CO2
Refinery
Oil
Natural Gas
Methanol
Plant
Methanol
MTBE
Fertilizer
Plant
Ammonia
Urea
Main Products
CO_2 Emissions

Step 1: Data acquisition for industrial zone



70%

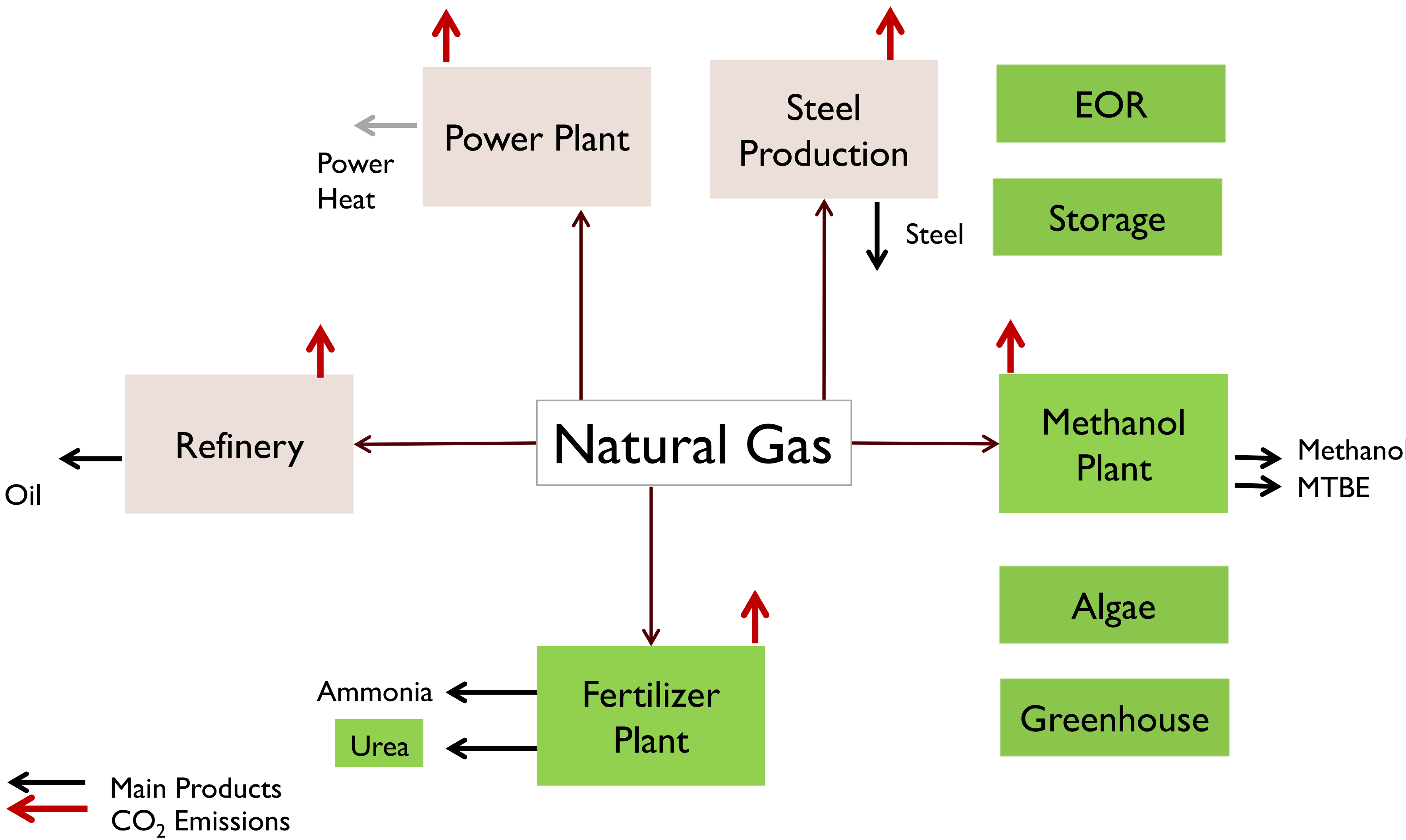
Of emissions accounted for in selected sources

Step 1: Data acquisition for industrial zone

- CO2 Source Information

Plant	Source	CO2 Flow, MTPD	Composition of CO2, wt%	P, kPa	T, K
Ammonia	amine unit	977	100%	101 kPa	298 K
Steel	Iron Mill	3451	44%		
Power	Gas Turbine	9385	7%		
Refinery	Boiler	1092	27%		

Step 2: Identification of carbon sinks



Step 2: Identification of carbon sinks

- CO_2 Sink Information
  - Enhanced Oil Recovery
  - Storage in Saline Aquifers
  - Boasting Urea Production
  - Methanol Production using Solar Energy
  - Microalgae Production
  - Greenhouses

Step 2: Identification of carbon sinks

- CO_2 Sink Information

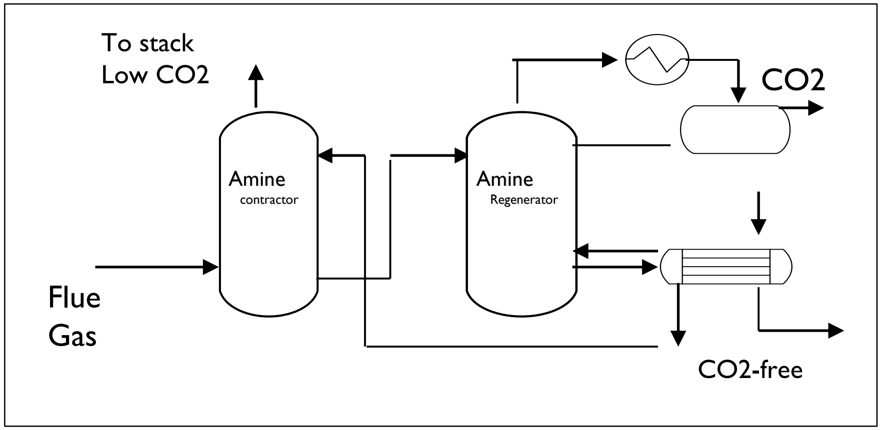
Sinks	CO_2 Composition (wt%)	Flow CO_2, MTPD	P, kPa	C^{sink}_{k}, USD/ton CO_2 *	η_k
Algae	6	283	101	0	0.42
Greenhouses**	94	1030	101	-5	0.5
Methanol	99.9	1710	8080	-21	0.098
Urea	99.9	1126	14140	-15	0.39
CO_2-EOR **	94	2739	15198	-30	0
Saline Storage **	94	8317	15198	8.6	0

- *based on information from the IPCC report (Metz et al, 2005), (European Commission, 2007), (Campbell et al 2009), (Bloom et al, 2009), (Van-Dal et al 2013), (Global CSS, 2011) and (Kojima et al, 2008).
- **located out of the city

- Negative cost indicates a profit

Step 3: Treatment, transmission and cost data

- Carbon removal cost from each source
  - Technology of choice: MEA Absorption
  - Literature Values



Plant	Source	Estimated C_{si}^{T}
Ammonia Plant	Amine Unit	0
Steel Plant	Iron Mill	29
Power Plant	Gas Turbine	43
Refinery	Boiler	35

- Costs estimation based on Hendrix and Graus (2004) and Rubin et al (2012)

Step 3: Treatment, transmission and cost data

- Compression and Pumping Correlations
  - Capital + Operating Cost

Cost Element	Correlation	source
Capital cost of compressor	$CC^{capital}\left(\frac{\text{USD}}{\text{yr}}\right) = 158{,}902\left(\frac{\mathrm{P}^{comp}.(\mathrm{T}_{s,k,t}+\mathrm{U}_{s,k})}{224}\right)^{0.84} CRF$	Durao (2008)
Operating cost of compressor	$CC^{operating}\left(\frac{\text{USD}}{\text{yr}}\right) = \mathrm{P}^{comp}.(\mathrm{T}_{s,k,t}+\mathrm{U}_{s,k}) * Elec.\left(\frac{USD}{kWh}\right) * \left(\frac{days}{year}\right) * 24\,h$	
The overall cost of compressor	$C_{s,k}^{Compessor}\left(\frac{\text{USD}}{\text{yr}}\right) = CC^{capital} + CC^{operating}$	
Capital cost of pump	$PC^{capital}\left(\frac{\text{USD}}{\text{yr}}\right) = [(1.11 * 10^6\,\frac{P^{pump}.(\mathrm{T}_{s,k,t}+\mathrm{U}_{s,k})}{1000} + 0.07 * 10^6) * CRF)]$	McCollum and Ogden (2006)
Operating cost of pump	$PC^{operating}\left(\frac{\text{USD}}{\text{yr}}\right) = 0.8 * P^{pump}.(\mathrm{T}_{s,k,t}+\mathrm{U}_{s,k}) * Elec.\left(\frac{USD}{kWh}\right) * \left(\frac{days}{year}\right) * 24\,h$	
Total overall cost of pump	$C_{s,k}^{pump}\left(\frac{\text{USD}}{\text{yr}}\right) = PC^{capital} + PC^{operating}$	
Cost of piping	$\mathrm{C}_{s,k}{}^{\text{Pipe}}\left(\frac{\text{USD}}{\text{mi}}\right) = \left[95{,}230\left(D^{c}{}_{s,k}\right) + 96{,}904\right] * \mathrm{CRF}$	Parker (2004)

Step 3: Treatment, transmission and cost data

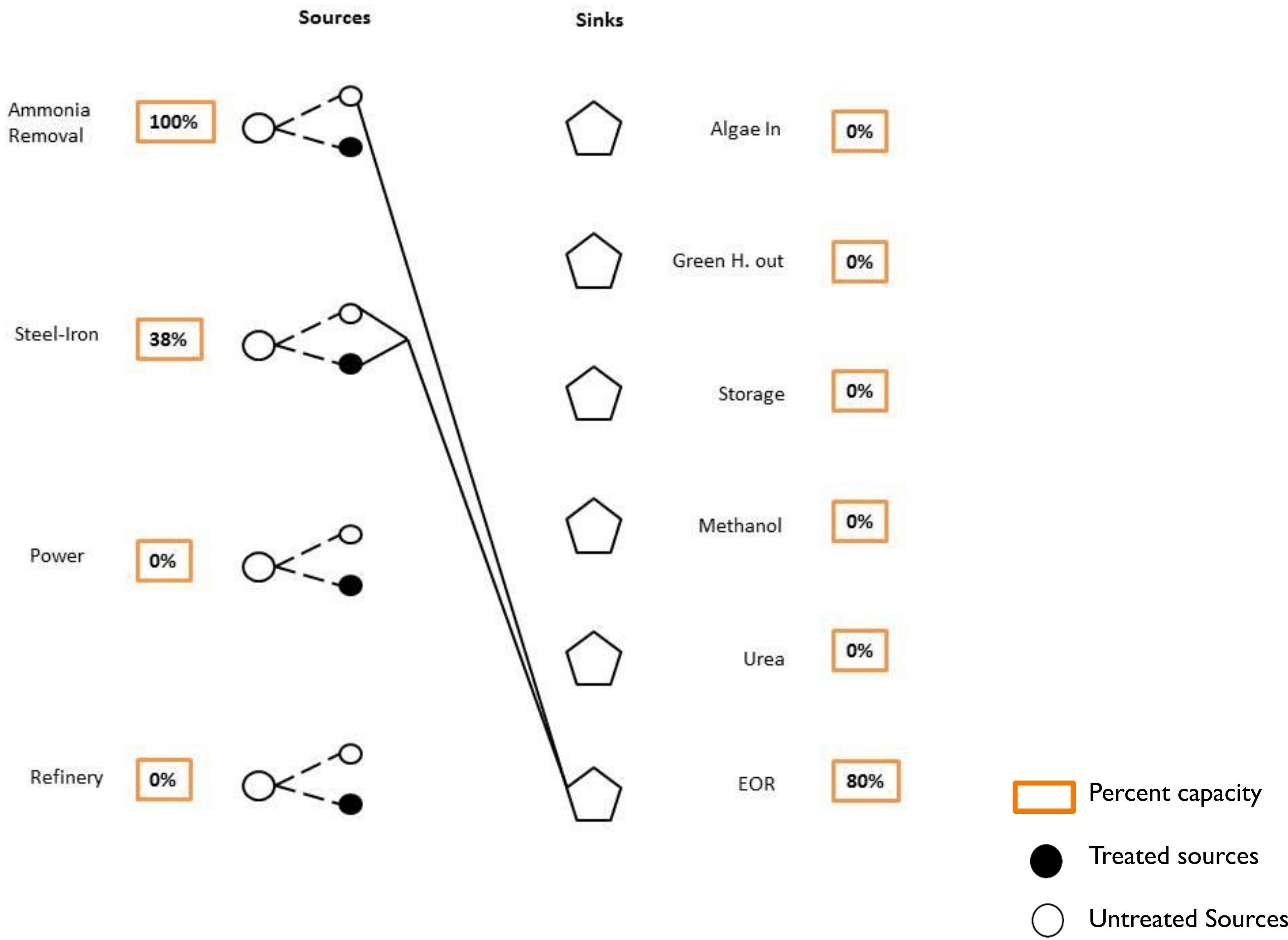
Cost Support Information

- Cost of electricity is 0.02USD/kWh (Qatar Electricity Tariffs, 2014)
- Capital Recovery Factor (CRF) = 0.15
- Distances between sources and sinks

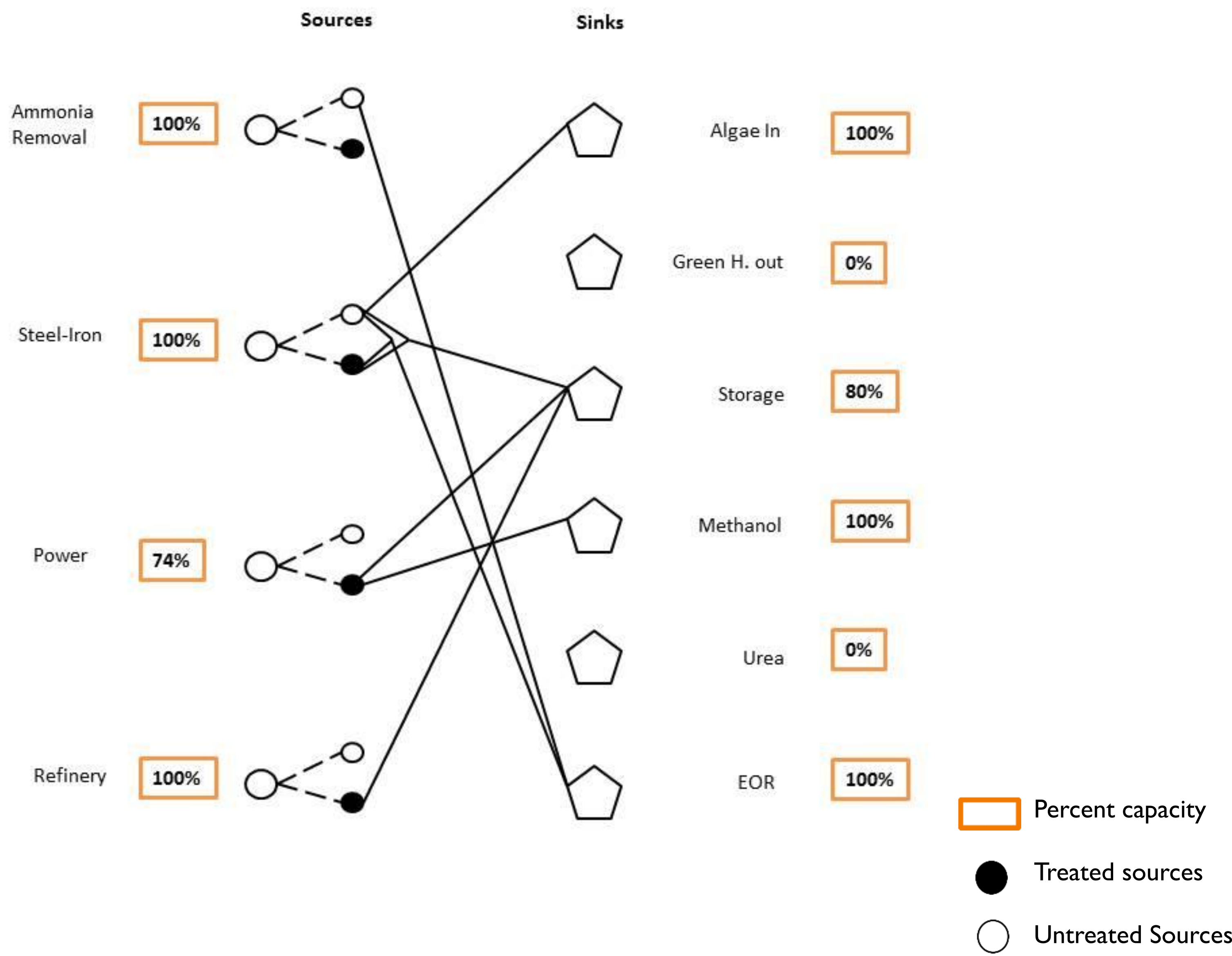
source/sink	Algae	Greenhouses	Storage	Solar Methanol	Urea Plant	Enhanced Oil Recovery
Ammonia – amine unit	1.72	25.38	1.51	1.51	1.55	1.56
Steel –Iron Mill	2.07	25.73	1.86	1.86	1.9	1.91
Power-Gas Turbine	2.77	27.33	2.95	2.95	0.91	0.51
Refinery - Boiler	2.53	27.09	2.71	2.71	0.66	0.82

Results and Discussion

10% Capture

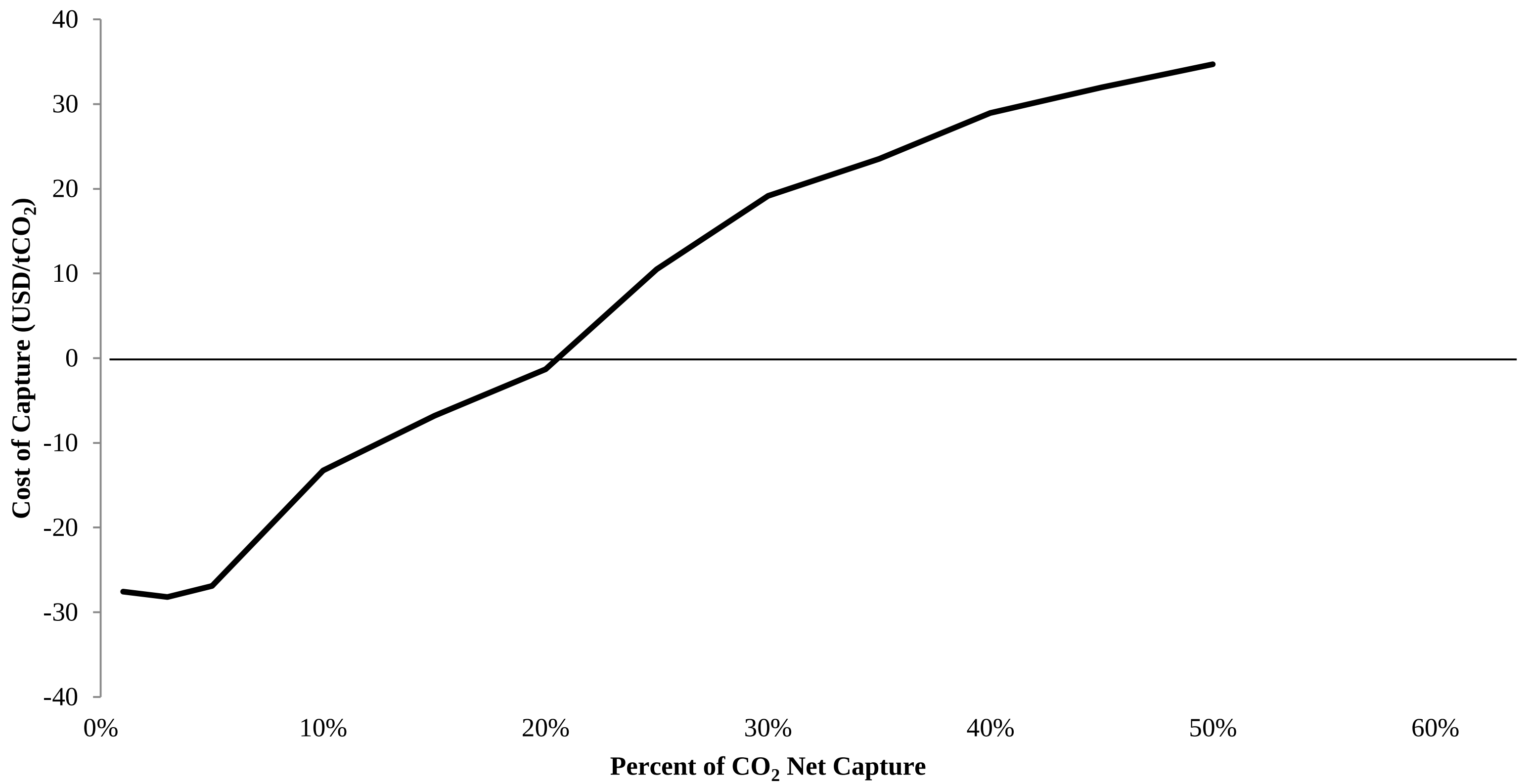

Sources
Sinks
Ammonia Removal
100%
Steel-Iron
38%
Power
0%
Refinery
0%
Algae In
0%
Green H. out
0%
Storage
0%
Methanol
0%
Urea
0%
EOR
80%
Percent capacity
Treated sources
Untreated Sources

40% Capture

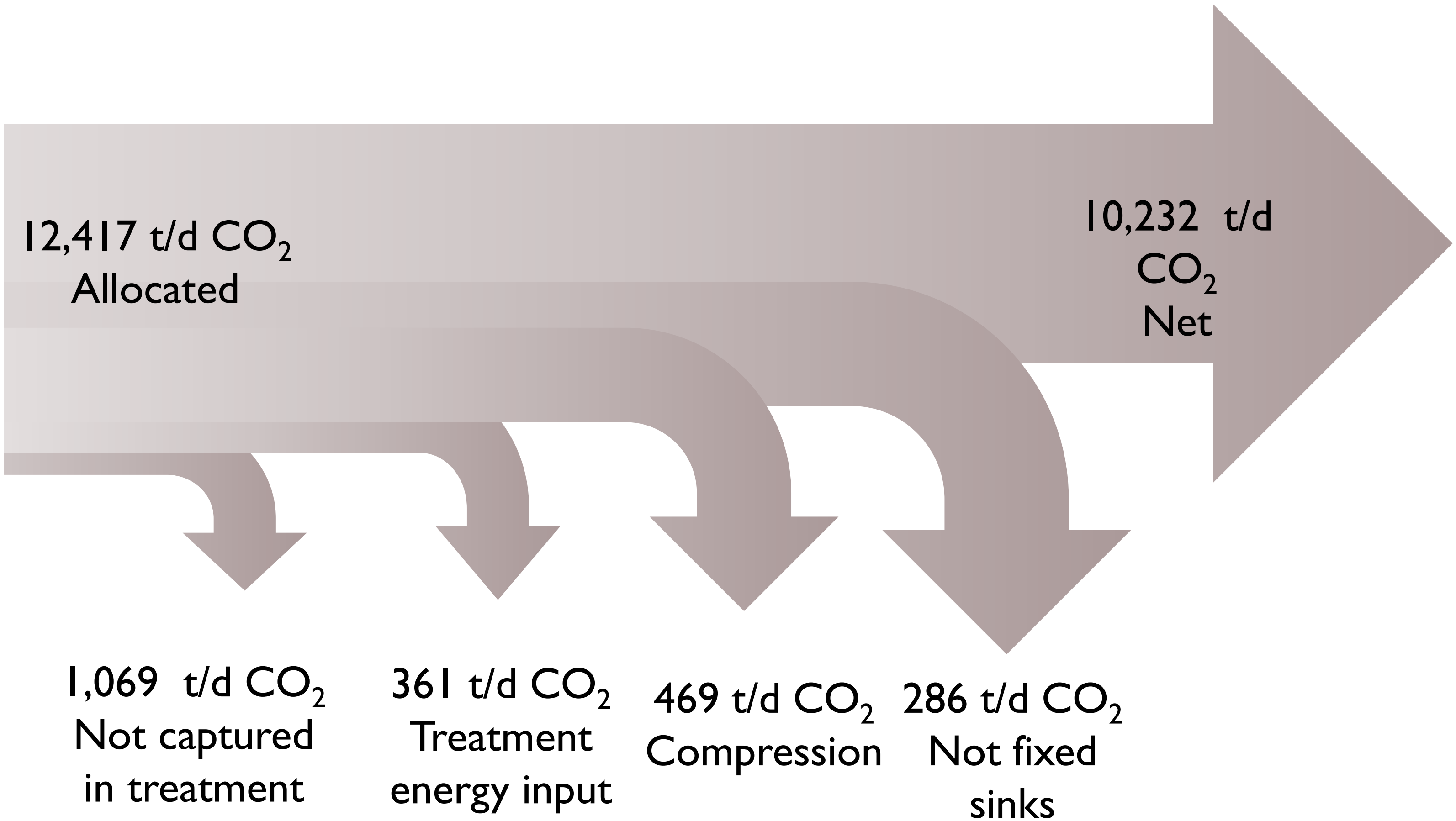


Sources
Sinks
Ammonia Removal
100%
Steel-Iron
100%
Power
74%
Refinery
100%
Algae In
100%
Green H. out
0%
Storage
80%
Methanol
100%
Urea
0%
EOR
100%
Percent capacity
Treated sources
Untreated Sources

Capture Cost per ton CO2 vs. Capture Target

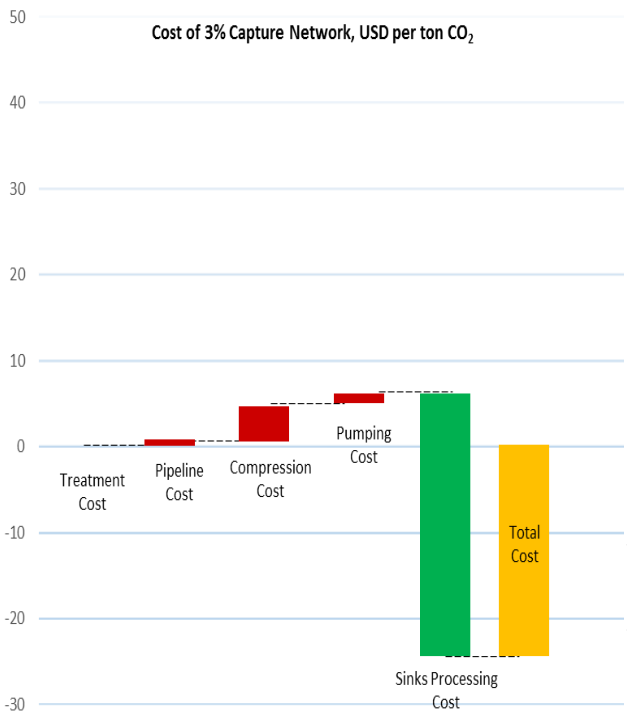


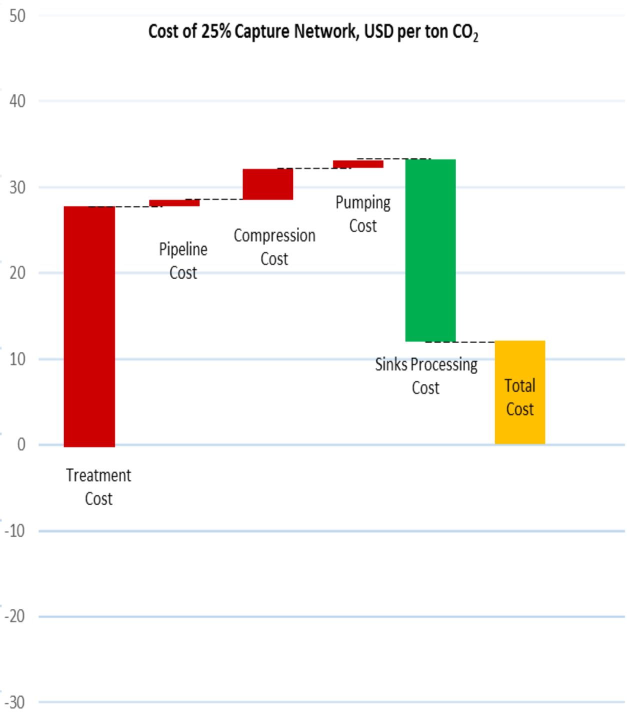
Carbon Dioxide Net Target

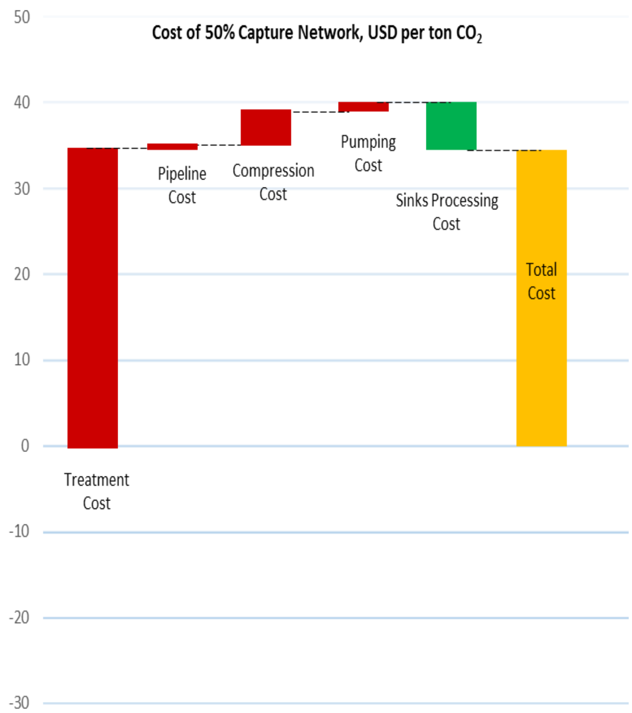


- 50% Capture Balance

Cost Breakdown







Summary

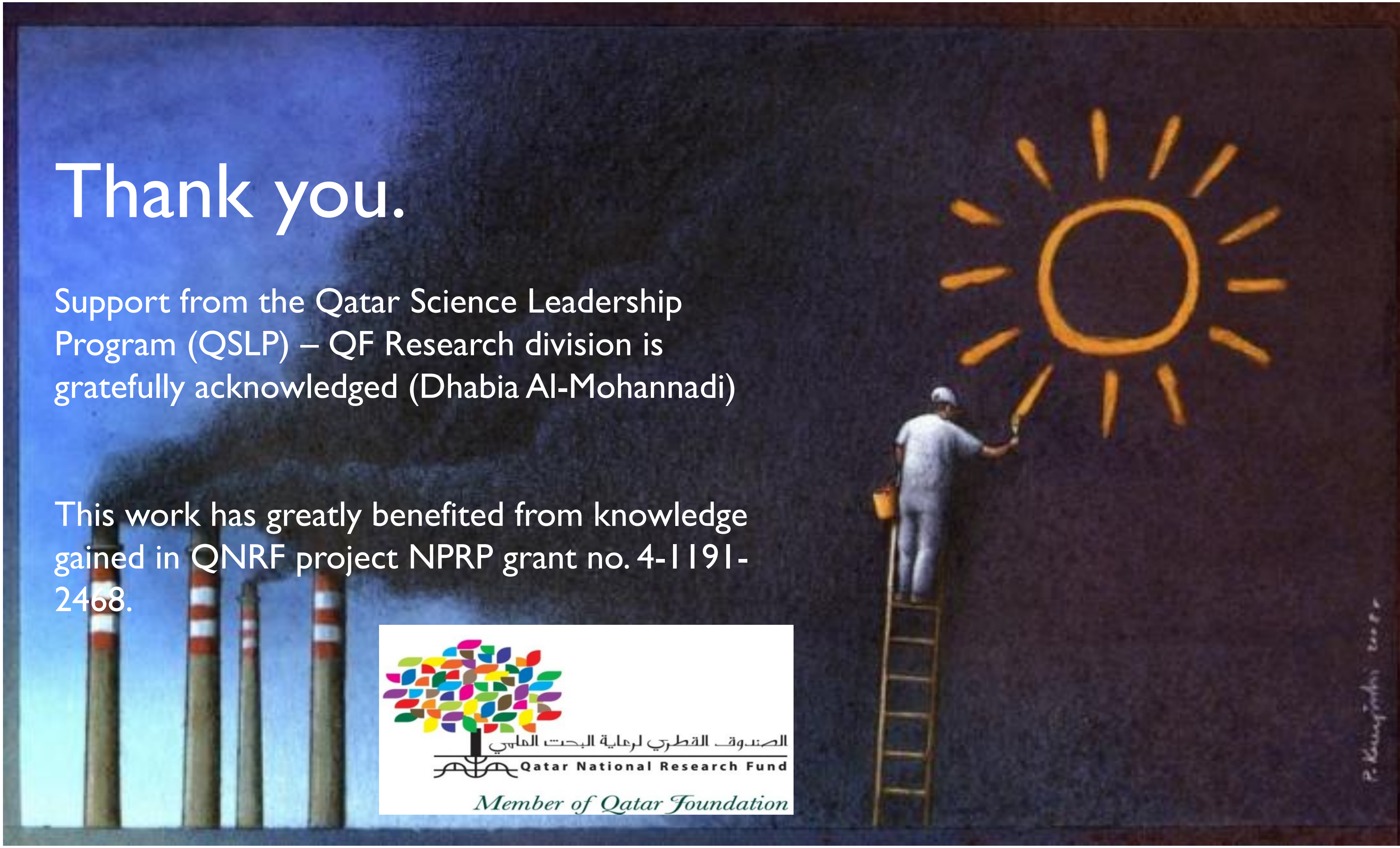
- Carbon integration:
  Systematic approach to identify low cost carbon management options across multiple sources and multiple sinks using CO2 purification as appropriate

- Focus on industrial parks / cities and interfaces to external CO2 sinks

- Enables exploration of scenarios to inform decision-making

Ongoing Work

- Integration for tightening reduction targets over time
- Carbon & Energy Integration (incl renewables)
- Integrated carbon dioxide separation technology selection



Thank you.

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الصندوق القطري لرعاية البحث العلمي

Qatar National Research Fund

Member of Qatar Foundation

Artist: Pawel Kuczynski

Some more slides

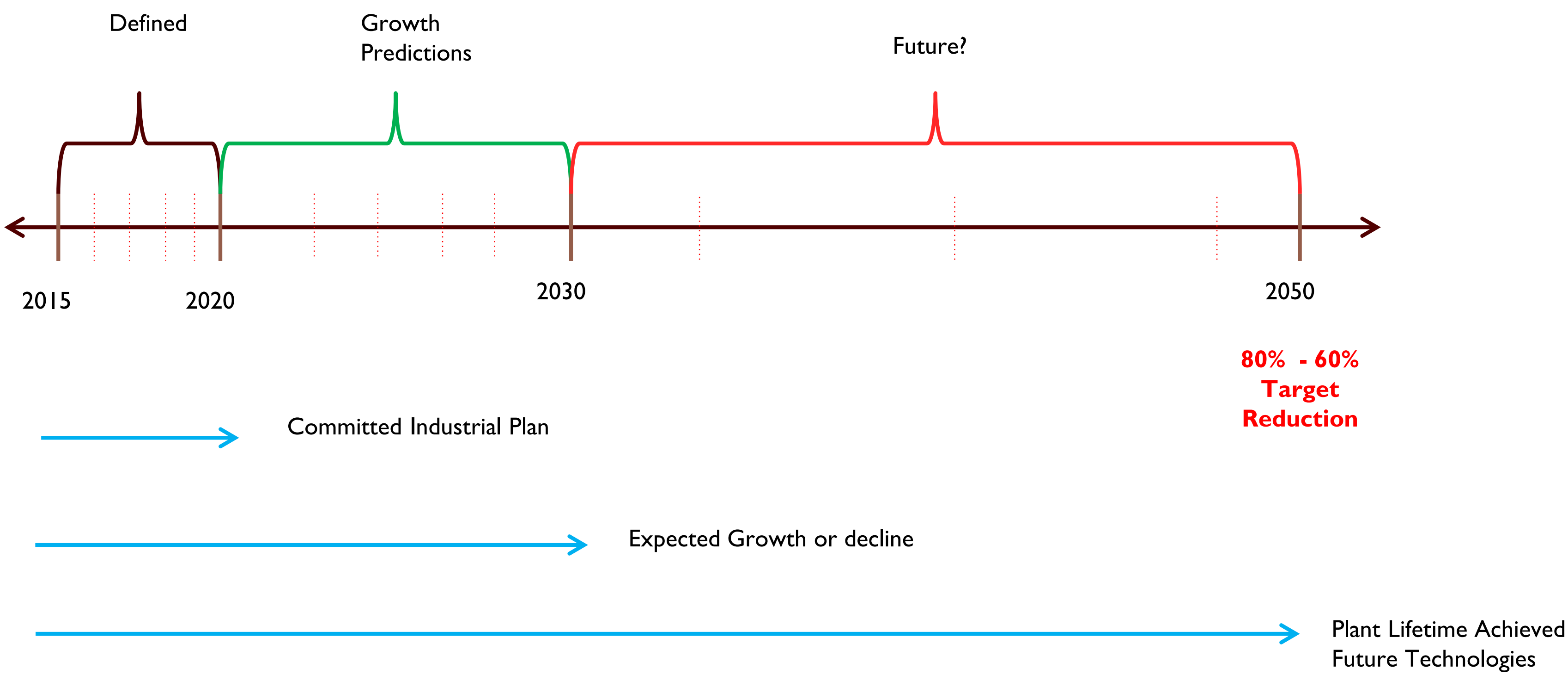
BACK-UP

Acknowledgement

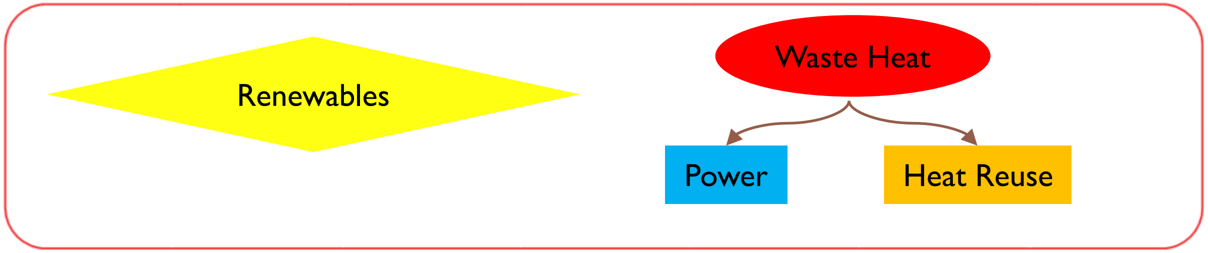
- Qatar Science Leadership Program (QSLP) – QF Research division (Dhabia Al-Mohannadi)

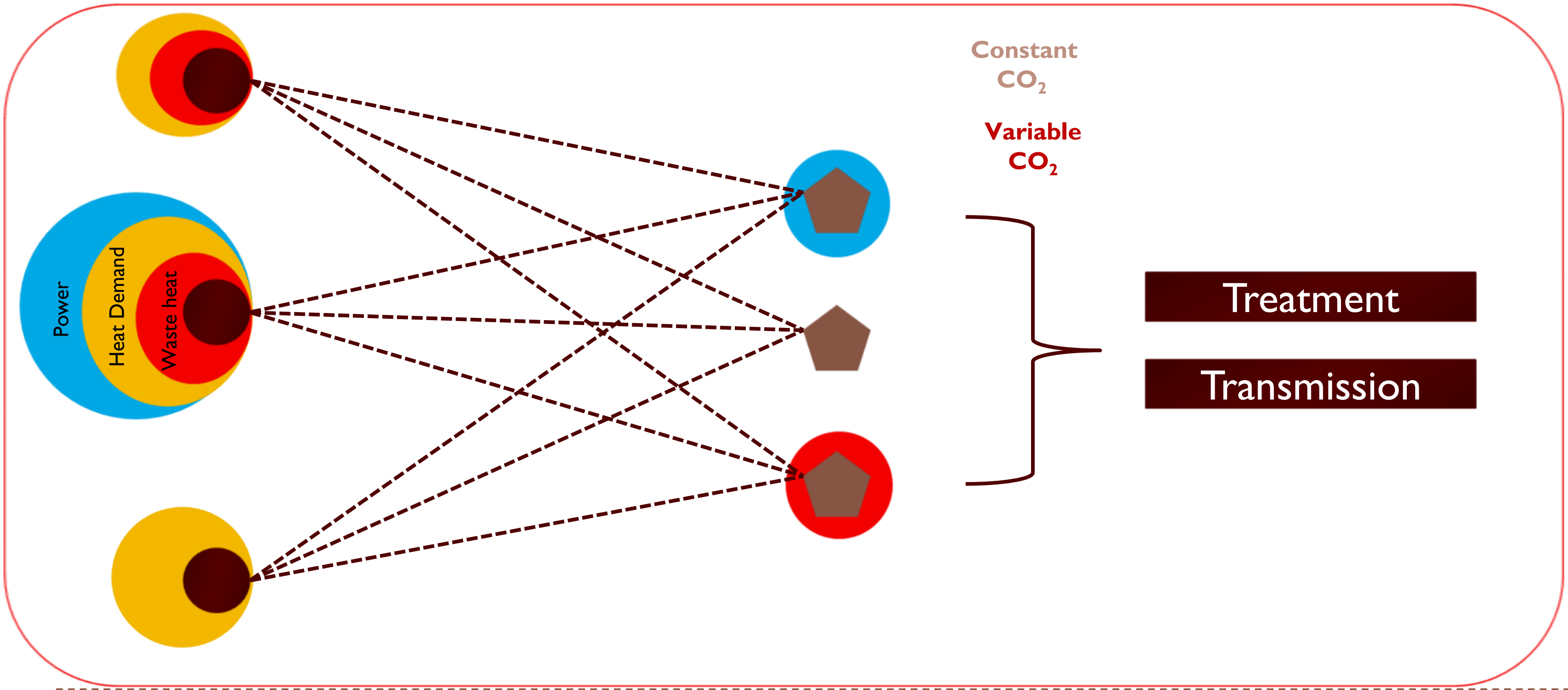
Ongoing Work: Achieving targets over time

Network Rearrangement

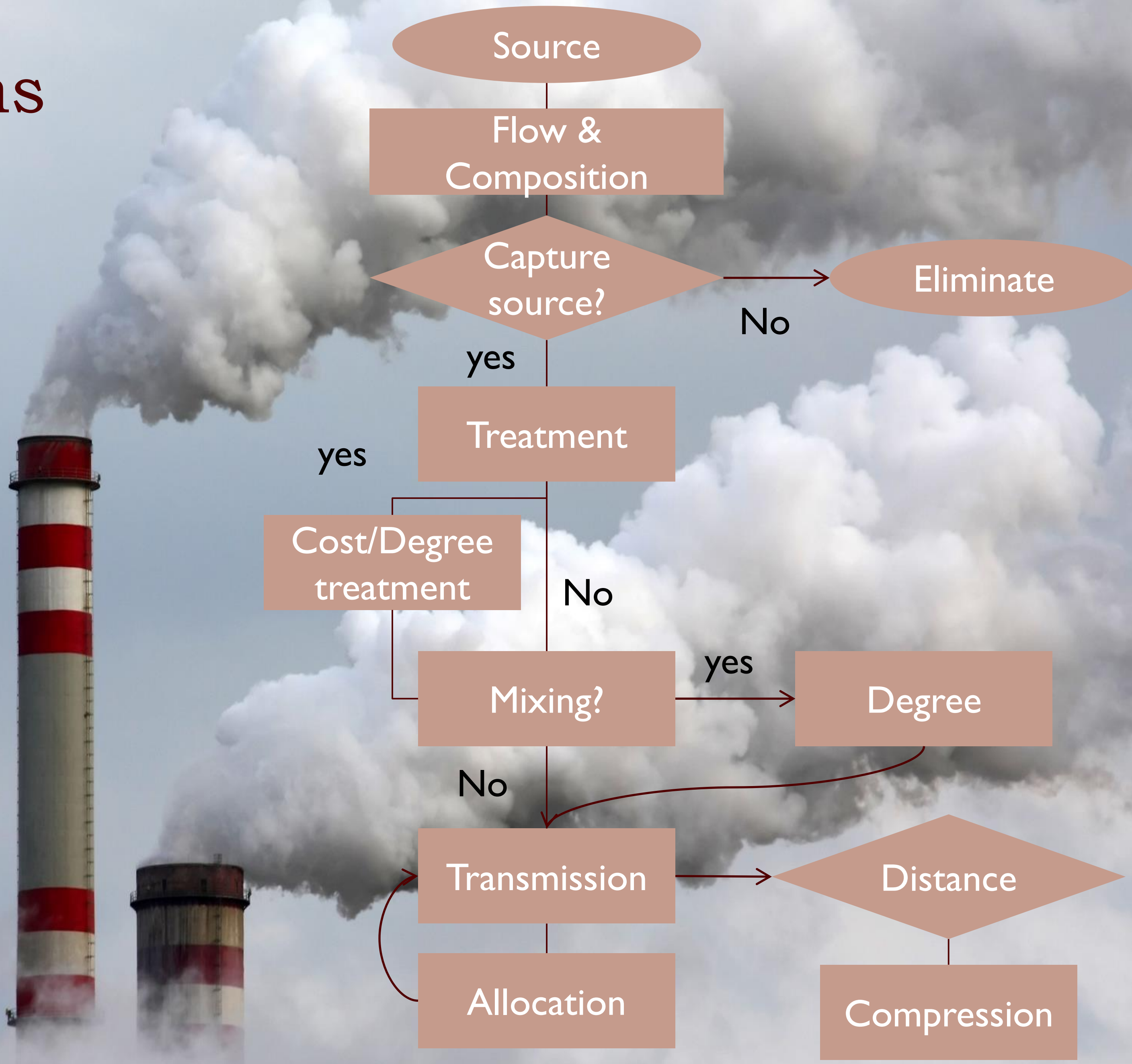


Ongoing Work:
Carbon & Energy Integration

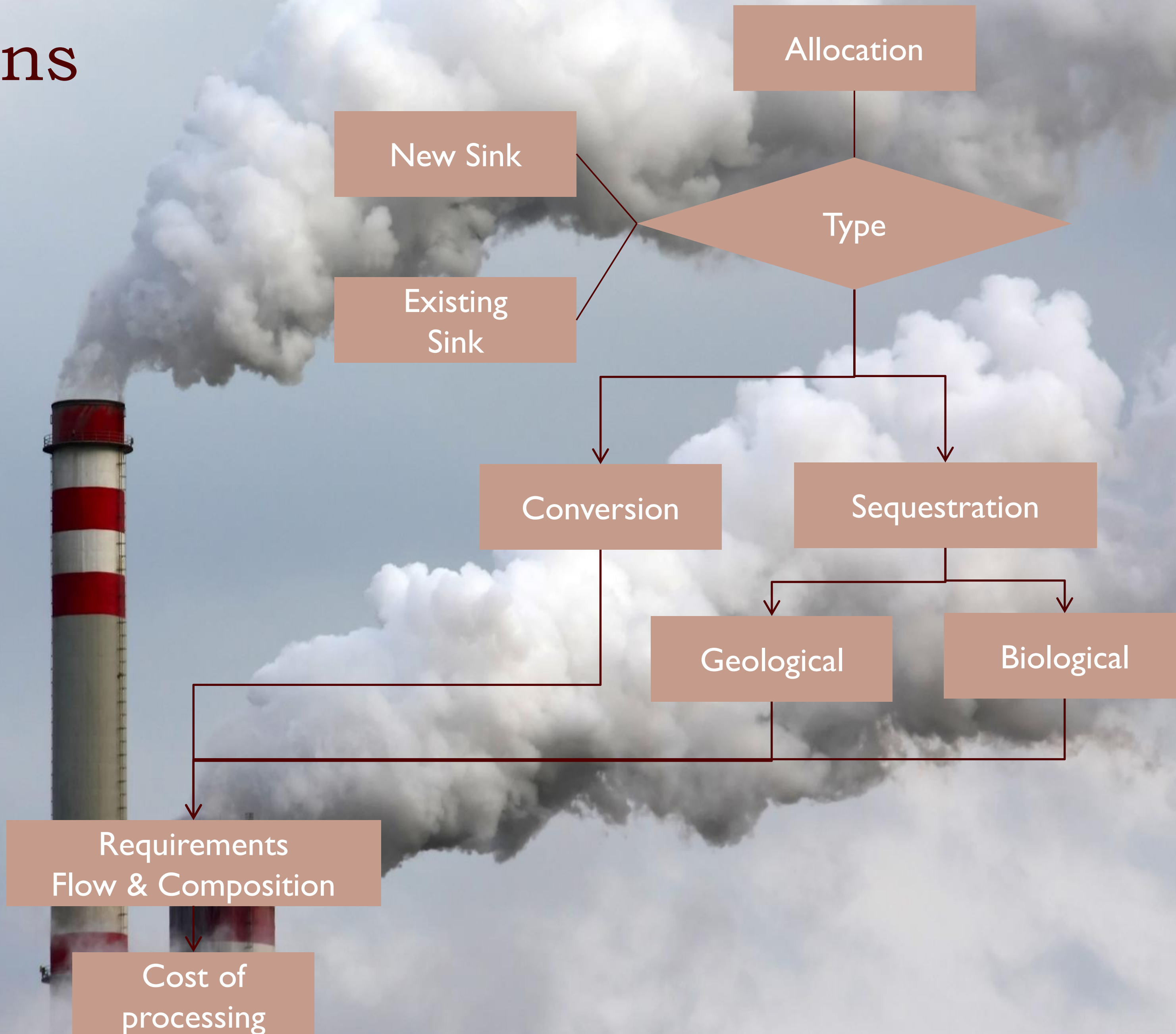




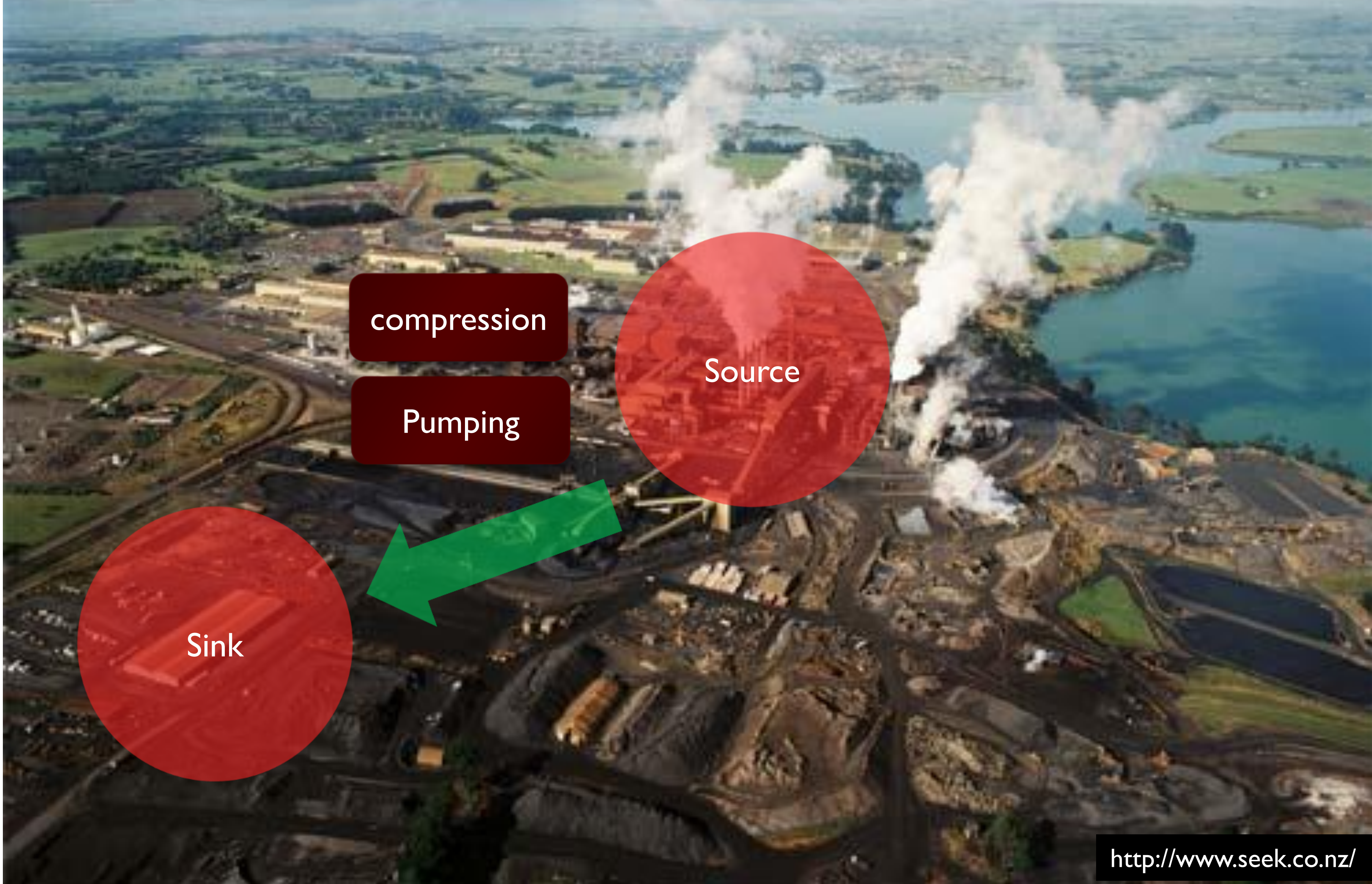
Decisions


Source
Flow & Composition
Capture source?
No
Eliminate
yes
Treatment
yes
Cost/Degree treatment
No
Mixing?
yes
Degree
No
Transmission
Distance
Allocation
Compression

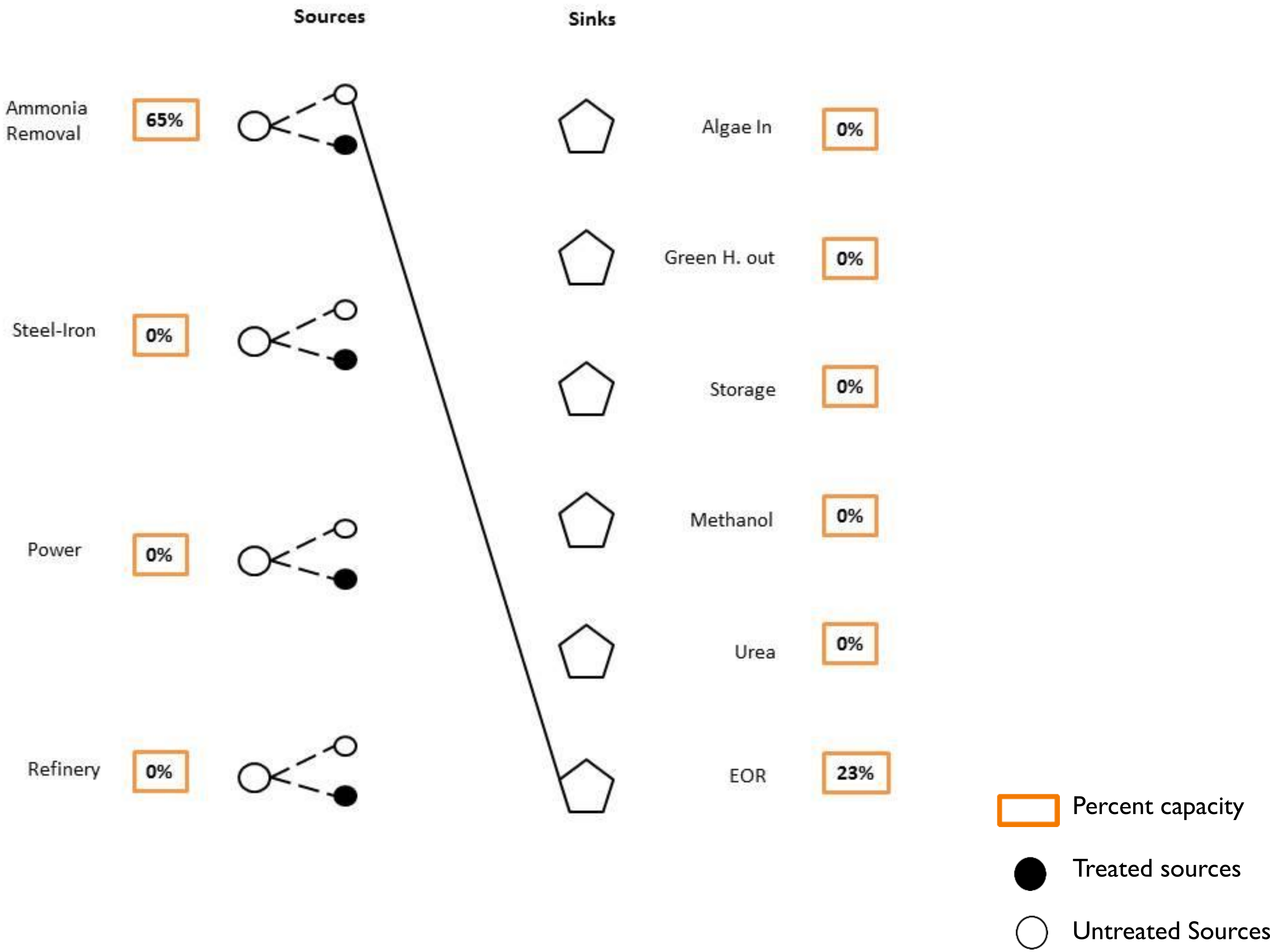
Decisions


Allocation
New Sink
Type
Existing Sink
Conversion
Sequestration
Geological
Biological
Requirements Flow & Composition
Cost of processing

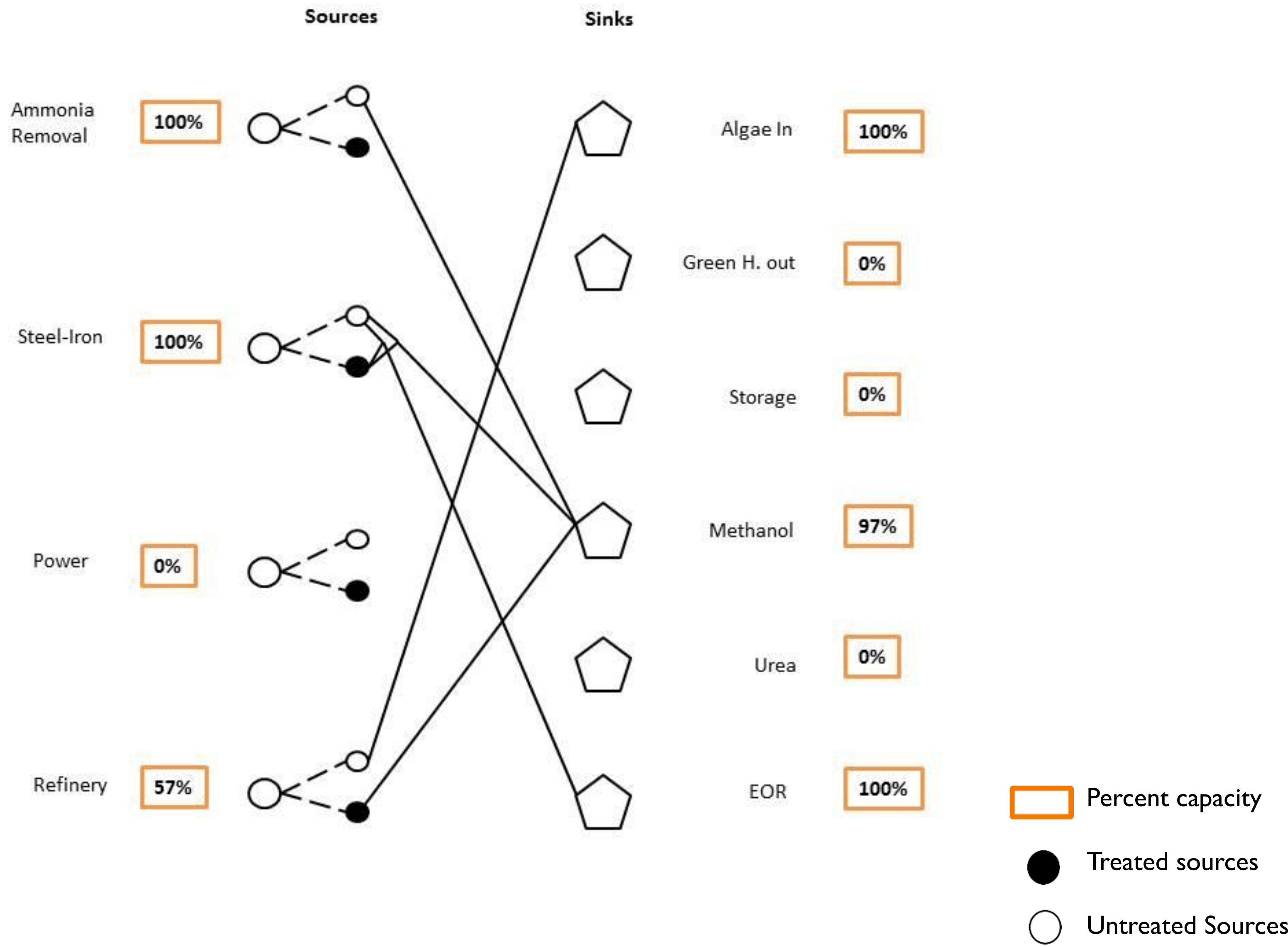
Connection



3% Capture


Sources
Sinks
Ammonia Removal
65%
Steel-Iron
0%
Power
0%
Refinery
0%
Algae In
0%
Green H. out
0%
Storage
0%
Methanol
0%
Urea
0%
EOR
23%
Percent capacity
Treated sources
Untreated Sources

20% Capture



Sources
Sinks
Ammonia Removal
100%
Steel-Iron
100%
Power
0%
Refinery
57%
Algae In
100%
Green H. out
0%
Storage
0%
Methanol
97%
Urea
0%
EOR
100%
Percent capacity
Treated sources
Untreated Sources

STRONG TRACK RECORD OF

RESEARCH WITH INDUSTRY & LOCAL SERVICE

Government

- Emiri Diwan

- Ministries
  Ministry of the Environment
  Ministry of Development Planning and Statistics
  Ministry of Economy & Commerce

- Qatar Petroleum

Industry

- Q-Companies:
  QAFCO, QAPCO, QChem, QVC, QatarGas, RasGas

- Multi-Nationals and Technology:
  Shell, Maersk, BP, ExxonMobil, Sasol, Chevron, GDF Suez, Mitsubishi Heavy Industries

- Engineering / Services:
  Worley Parsons, URS, Bauer

Main reason for excellent reputation with local stakeholders (besides impact from our graduates)