

Optimization Framework for Facility-Level Petrochemical Decarbonization Analysis

Linear Programming Approach for Korean NDC Compliance Pathways

INPUT DATA MODULE

$F = \{F_1, F_2, \dots, F_N\}$

Korean petrochemical facilities  
• 8 companies, 3 regions, 24 processes

$T = \{T_1, T_2, \dots, T_M\}$

Alternative technologies  
• Heat pumps, e-crackers, H<sub>2</sub> systems

$C(F, T, P)$

Cost parameters  
• CAPEX, OPEX, fuel costs (2023-2050)

LINEAR PROGRAMMING OPTIMIZATION ENGINE

Objective Function:

minimize  $\sum_f \sum_t \sum_p C_{f,t,p} \cdot x_{f,t,p}$

Decision Variables:

$x_{f,t,p} \in [0, 1]$     $y_{f,t} \in \{0, 1\}$     $z_{f,t} \in \{0, 1\}$

Emission Target:

$\sum_f \sum_t \sum_p E_{f,t,p} \cdot x_{f,t,p} \leq E_{required}$

Technology Selection:

$\sum_t y_{f,t} \leq 1 \quad \forall f$

Capacity Limits:

$x_{f,t,p} \leq Cap_{f,t,p} \cdot y_{f,t} \quad \forall f, t, p$

Technical Readiness:

$x_{f,t,p} = 0$  if  $Year_t < Year_{min}$

CBC

OUTPUT ANALYSIS MODULE

$X^* = \{x_{f,t,p}^*\}$

Optimal deployment plan  
• Technology roadmap by facility

MACC Curve

Cost-effectiveness ranking  
• LCOA: \$2,753/tCO<sub>2</sub> (2030)

Policy Analysis

NDC compliance pathways  
• Investment: \$181.4B (2030)

KOREAN NDC TARGETS

2030: 15%   2040: 50%   2050: 80% emission reduction

KEY FINDINGS

2030 Target: Achievable via heat pump deployment (6.1 MtCO<sub>2</sub> reduction) • 2040/2050: Requires technology portfolio expansion • Total viable options: 39 technology-facility combinations