FLUOR®

ENERGY EFFICIENT CARBON CAPTURE WITH PROVEN SOLVENT TECHNOLOGY

A HEAT INTEGRATION STUDY

SANDER BALKENENDE

PCCC-8 MARSEILLE

OUTLINE

Energy Efficient Carbon Capture with Proven Solvent Technology

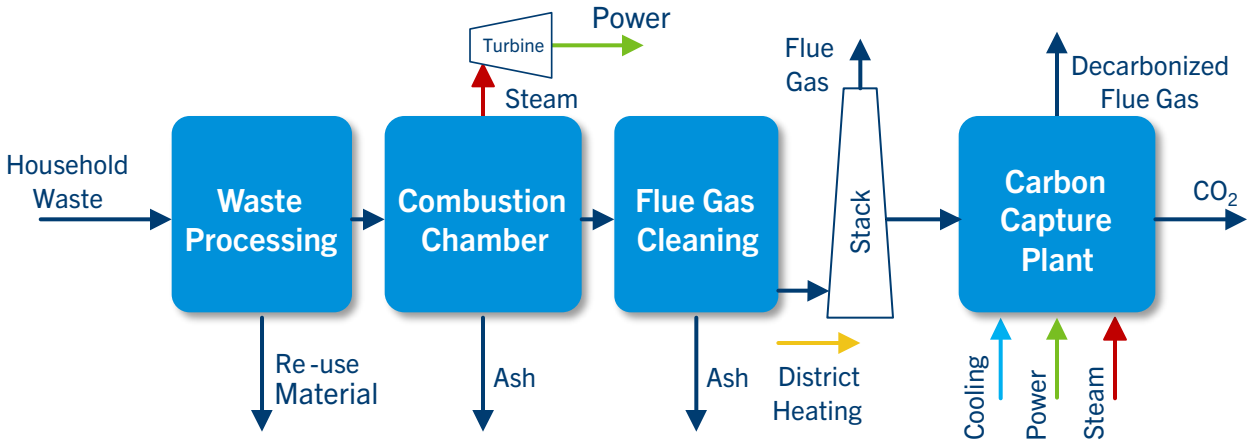
- Introduction
  - Client, study scope
  - Technology
  - Method
- Heat integration options
- Study results
- Conclusions

INTRODUCTION

Client & Project

- Client is a leading Waste to Energy company
  - Incinerates household waste
  - Delivers steam & power to surrounding industries
  - Delivers heat to city district heating, around 80-100°C
- Targets CO_2 neutral operation across their operations

- Fluor scope
  - Pre-FEED for a Carbon Capture plant, based on
  - Fluor's Econamine FG Plus℠ Carbon Capture Technology
  - Approx 500 kta CO_2 capture

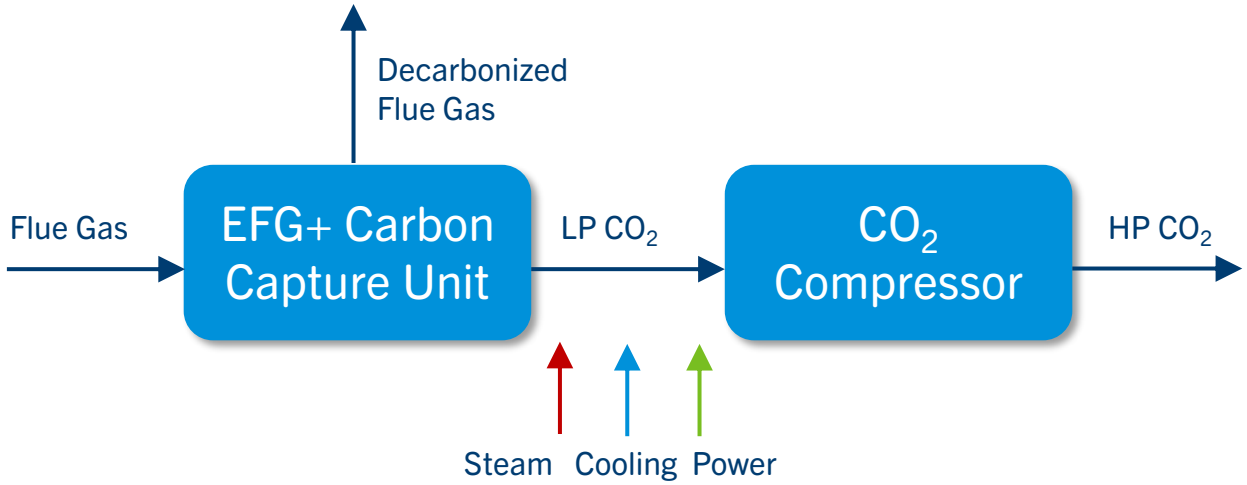


INTRODUCTION

Technology and Method

- Fluor's Econamine FG Plus^{SM} technology
- Low pressure, solvent-based carbon capture
- Consumes steam, electricity and cooling water

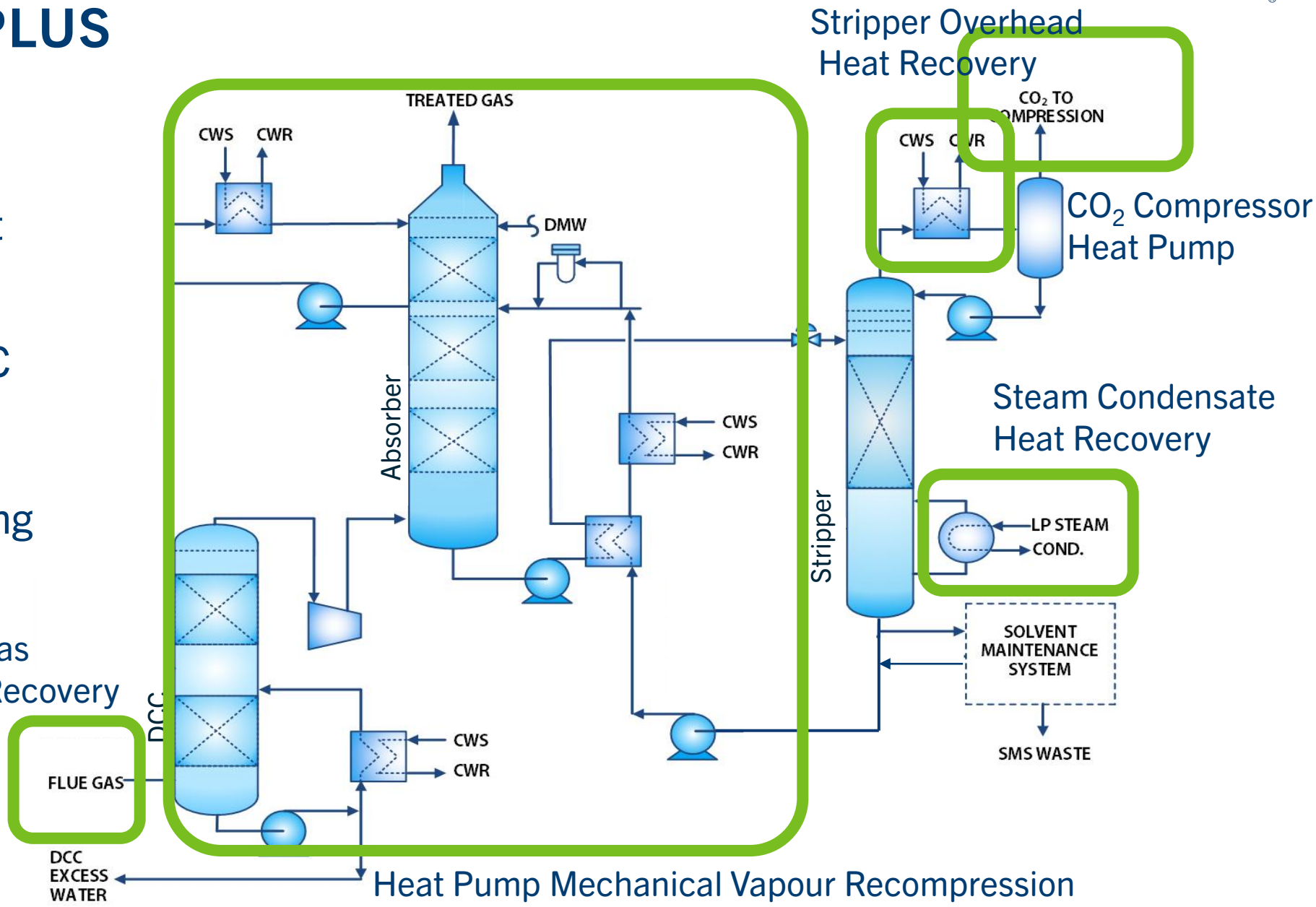
- Study to reduce energy consumption
  - Listing of individual heat integration options
  - Assessment of OPEX and CAPEX
  - Evaluation & ranking of options



ECONAMINE FG PLUS

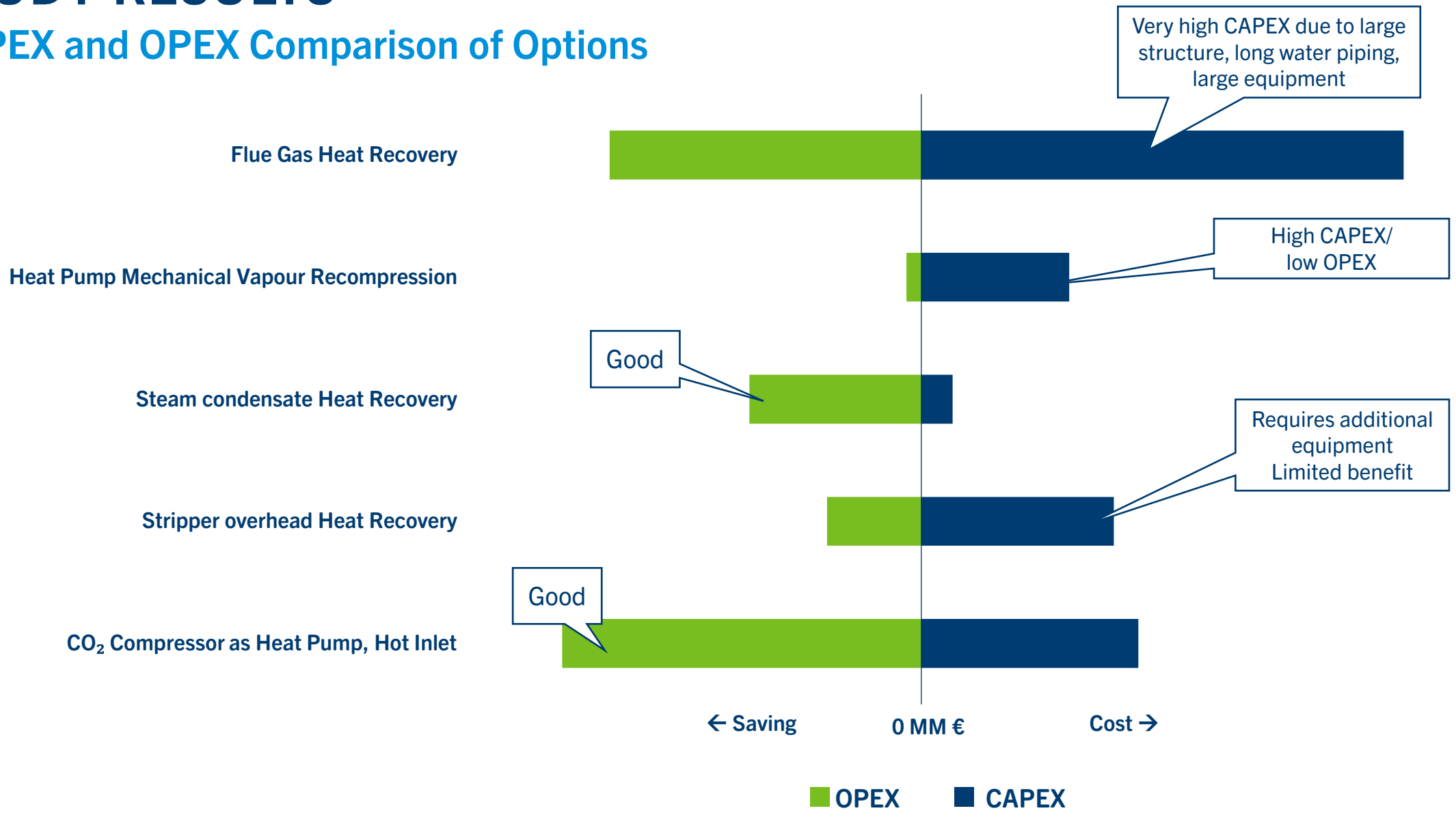
Heat Integration Options

- **High** temperature heat sources
  → directly to district heating system at 80°C
- **Low** temperature heat sources
  → require heat pumping to district heating



STUDY RESULTS

CAPEX and OPEX Comparison of Options



STUDY RESULTS

Traditional Heat Pumps

- Coefficient of Performance (COP)

$$COP_{heat\ pump} = \frac{Output\ Energy}{Input\ Energy} = \frac{Heat\ Out\ (MW)}{Electricity\ In\ (MW)}$$

- Heat pump economic viability:

$$Viability\ ratio = \frac{value\ of\ electricity\ (\frac{€}{MWh})}{value\ of\ heat\ (\frac{€}{MWh})} < COP_{heat\ pump}$$

Lower is better!

- High temperature lift for this project, resulting in low COP, too close to the viability ratio

→ Traditional heat pumps are not viable in this case

However……

Thanks Sabino!

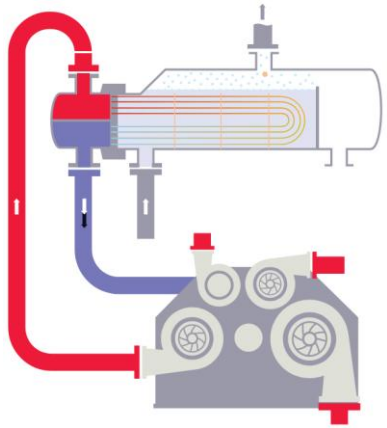
STUDY RESULTS

CO_2 Compressor as Heat Pump

- Four stage CO_2 compressor produces significant amount of heat in intercoolers
- When intercooled with hot water
  - Lower efficiency, but
  - Ability to transfer heat to district heating
- $COP = \frac{Heat\ recovery}{Delta\ compressor\ power} > 10$
- Machine cost ~ +20%
- Several vendors offer CO_2 compressors with stage inlet temperatures up to 200°C

MAN Energy Solutions is supplying the compressor system, for the carbon capture and storage (CCS) system at the Norcem Brevik cement plant of Heidelberg Materials in Norway

https://www.man-es.com/process-industry/solutions/carbon-captury-with-waste-heat-recovery#(EverIlence)



https://www.siemens-energy.com/global/en/home/products-services /product/integrally-geared-centrifugal-compressors.html

CONCLUSIONS

Carbon Capture Heat Integration

- Heat recovery from CO_2 compressor and reboiler steam condensate
  - Most promising for this project
- Heat recovery from incoming flue gas
  - Second best due to high investment
- Net energy consumption reduced by approximately 60%

- Ratio between monetary value of power and heat important for heat pump viability

- Heat integration can improve CO_2 Capture plant energy consumption significantly
  → due to local district heating

WHAT IS NEXT?

Carbon Capture Heat Integration

- Fluor is preparing for next project phase
  - FEED and EPC
- Scope facilities includes
  - CO_2 compressor heat recovery
  - Steam condensate heat recovery
  - Flue gas heat recovery (marked as future scope)

THANK YOU

QUESTIONS

LinkedIn
linkedin.com/company/fluor

X
@FluorCorp

YouTube
www.youtube.com/user/FluorCorporation

Sander Balkenende
Principal Process/Specialty Engineer
sander.balkenende@fluor.com