Solar Heat by Cogeneration

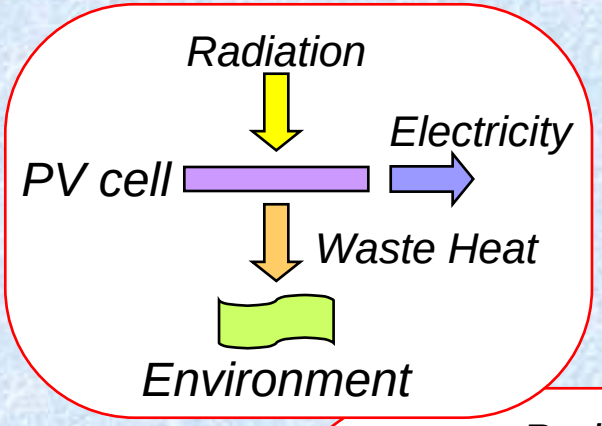
A. Kribus

School of Mechanical Engineering
Tel-Aviv University

Conversion of solar energy

PV

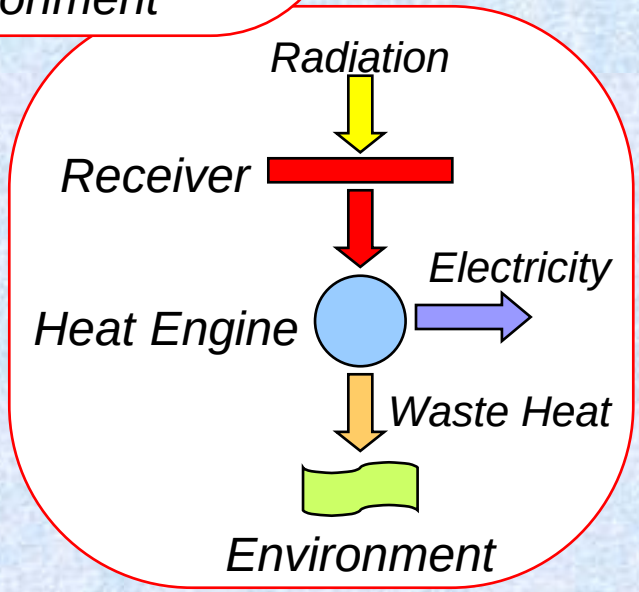
Radiation → Electricity



Thermal

Radiation → Heat

Radiation → Heat → Electricity



Co-generation: Use waste heat

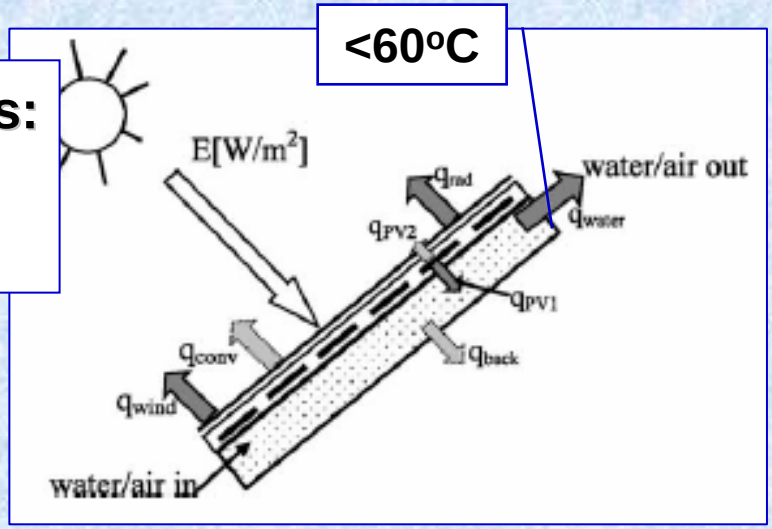
Waste heat → electricity

Waste heat as a product

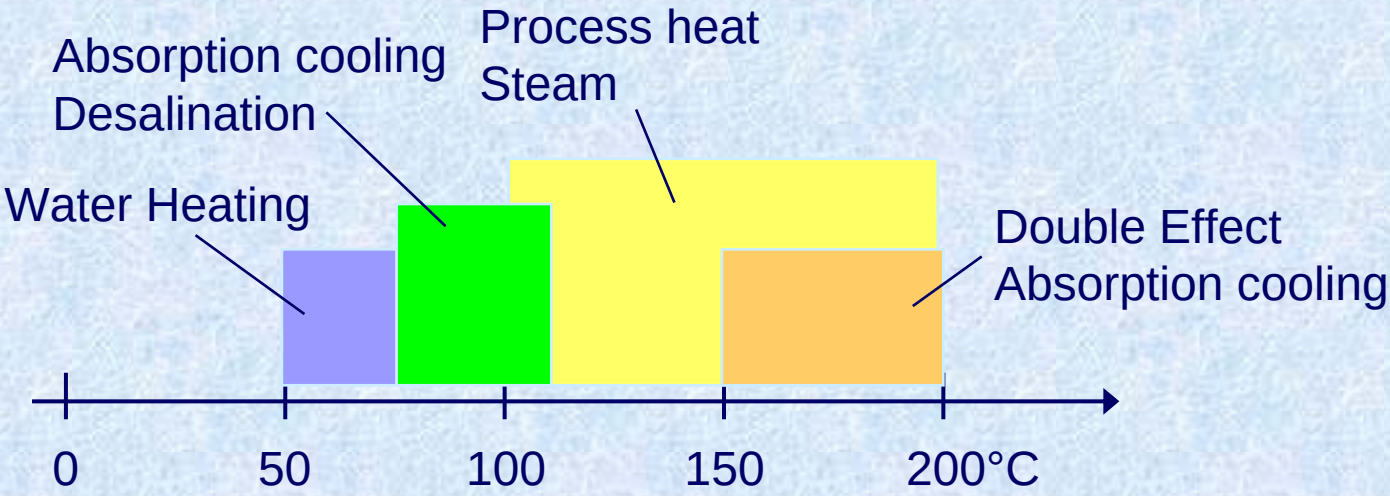
Waste heat → another energy product

PV + Thermal application

PV/T Collectors:
Water/space heating only

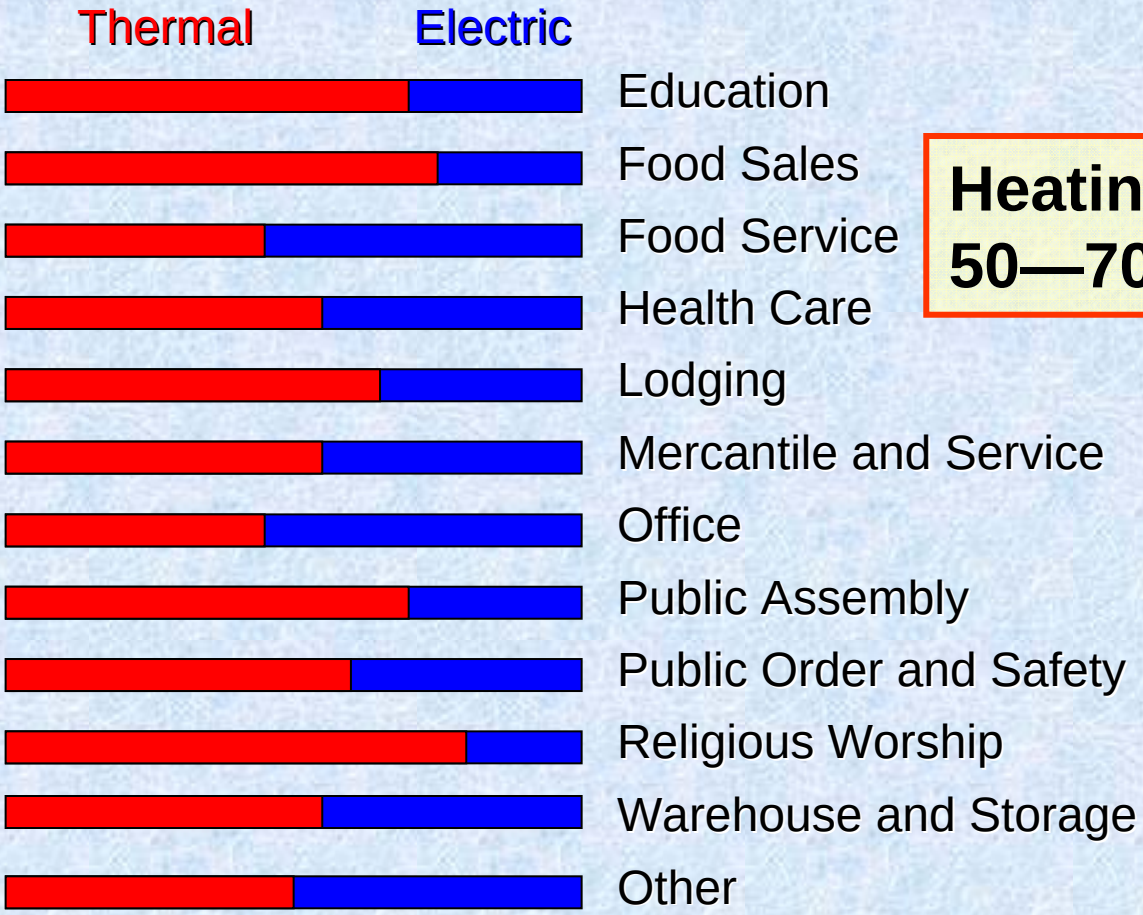


- **Concentration**
  Higher temperatures
  Wider range of applications



Energy Usage in Buildings

Source: EIA



Heating & cooling: 50—70% of load

Industrial Heat: Spain & Portugal

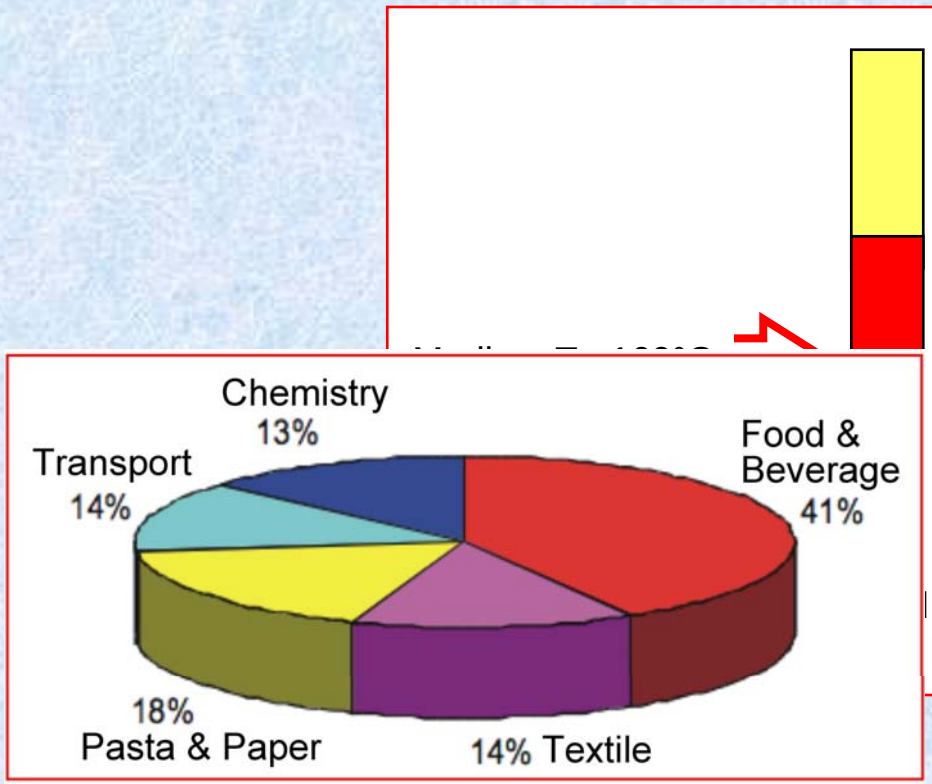
POSHIP Study, 2001

Total Heat in Industry: 20% of final energy consumption

Heat at low & medium temperature <160°C:

23% of total heat

4.6% of final energy consumption

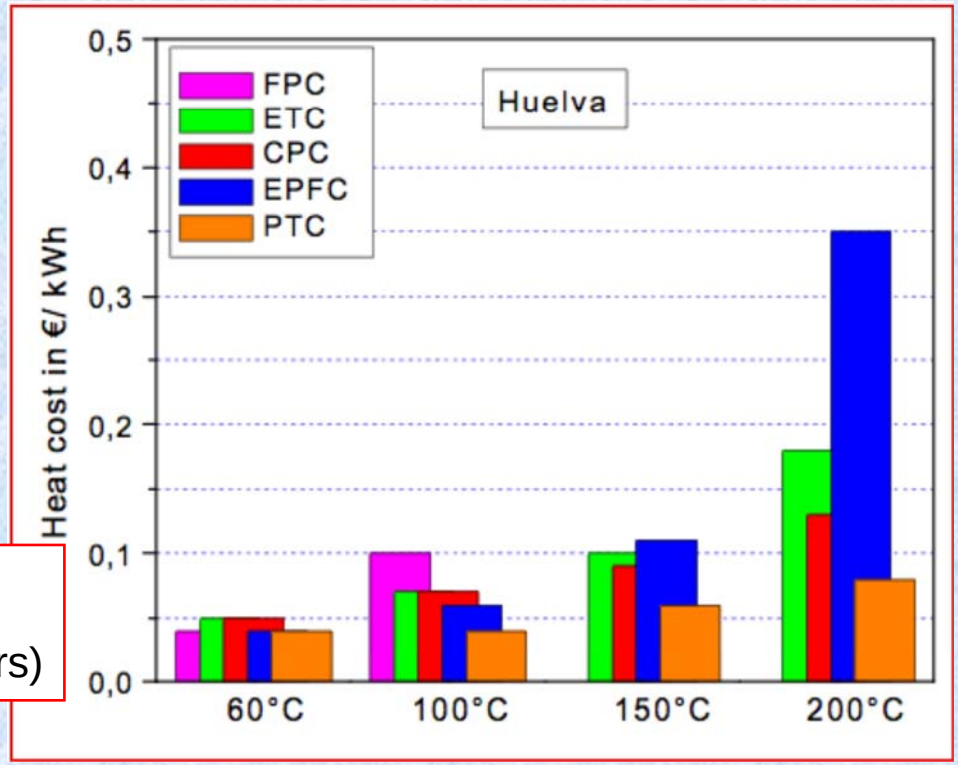


Efficiency & Cost

Spain:

Conventional fuel costs

0.025—0.045 €/kWh



Solar heat costs:

(Thermal collectors)

Cogeneration

Combined value of electricity & Heat

Electric, thermal output not equivalent

'Effective' output energy: $E_{Eff} = E_{EL} + \alpha \cdot E_{TH}$

Depends on thermal application

Value of thermal energy

CPVT + Absorption Heat Pump (AHP)

AHP replaces electric compressor

Overall efficiency ⇐ **Total electricity saved**

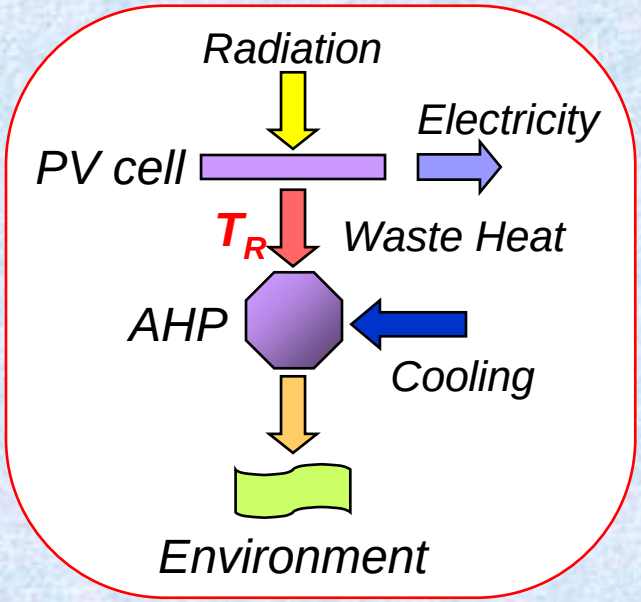
$$\eta = \eta_{opt}\eta_{PV} + \eta_{opt}\left(1-\eta_{PV}\right)\eta_{rec}\cdot\frac{COP_{AHP}}{COP_{ref}}$$

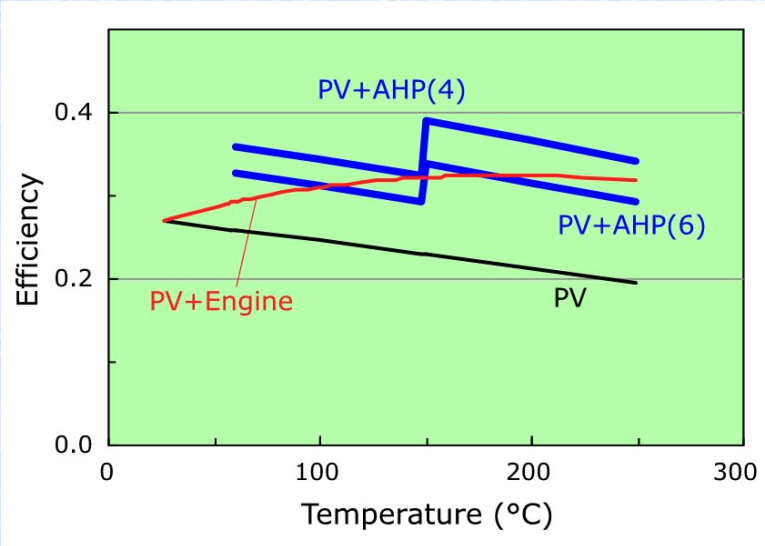
AHP COP = 0.7 for T_R>60°C

1.2 for T_R>150

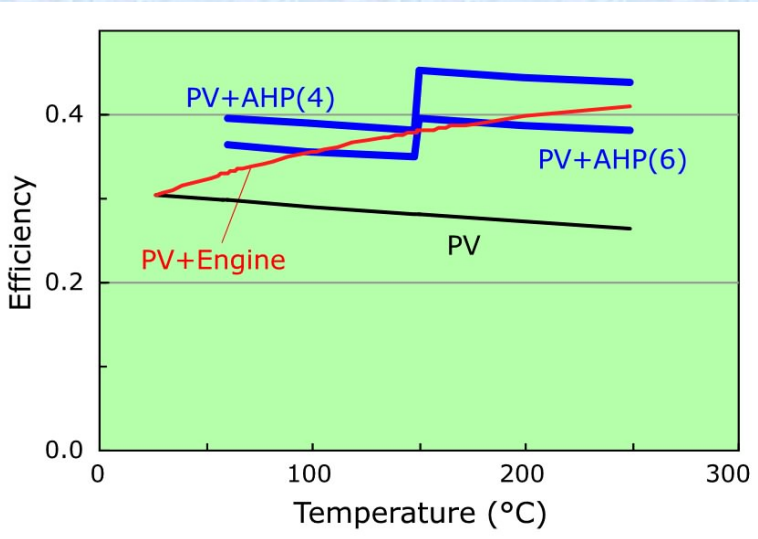
Reference compression chiller:

COP = 4—6





C = 50



C = 1,000

Heat Engine + AHP

AHP replaces electric compressor

Overall efficiency ⇐ **Total electricity saved**

$$\eta = \eta_{opt}\,\eta_{rec}\left[K\left(1-\frac{T_M}{T_H}\right)+\left(1-K+K\frac{T_M}{T_H}\right)\cdot\frac{COP_{AHP}}{COP_{ref}}\right]$$

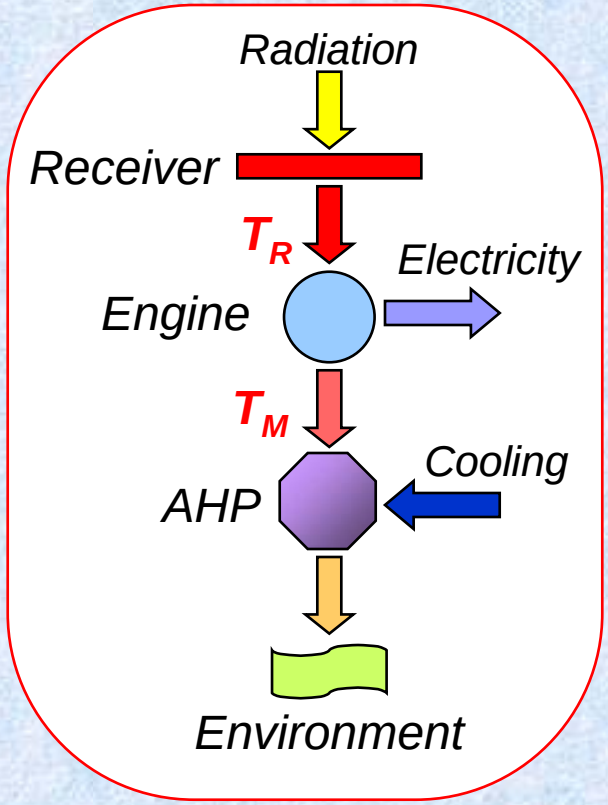
K = 0.6

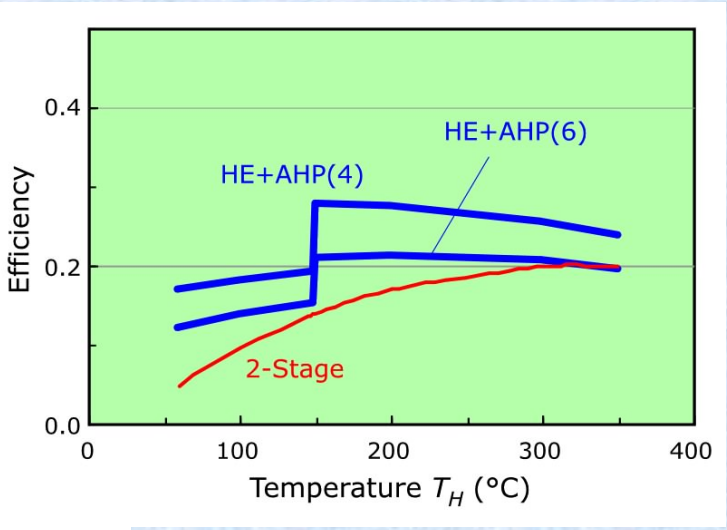
AHP COP = 0.7 for T_M = 60°C

1.2 for T_M = 150°C

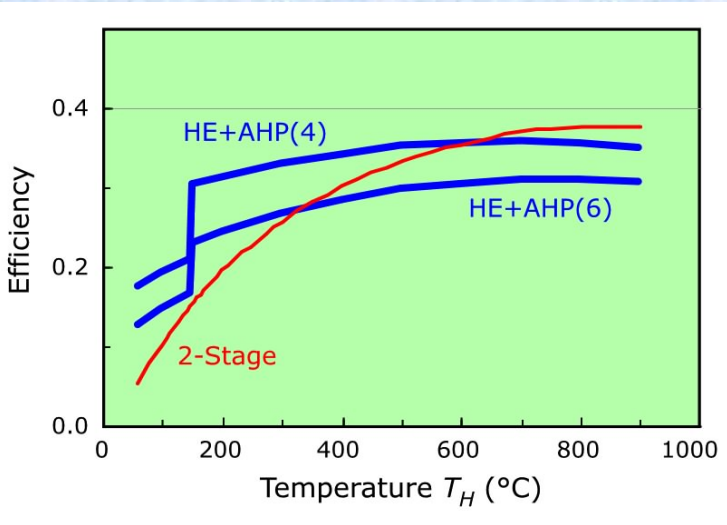
Reference compression chiller:

COP = 4—6



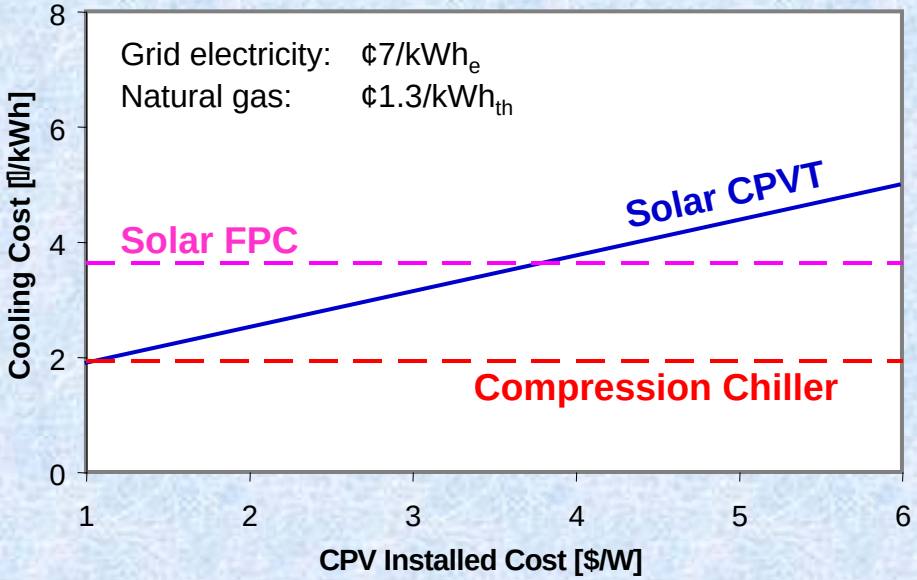


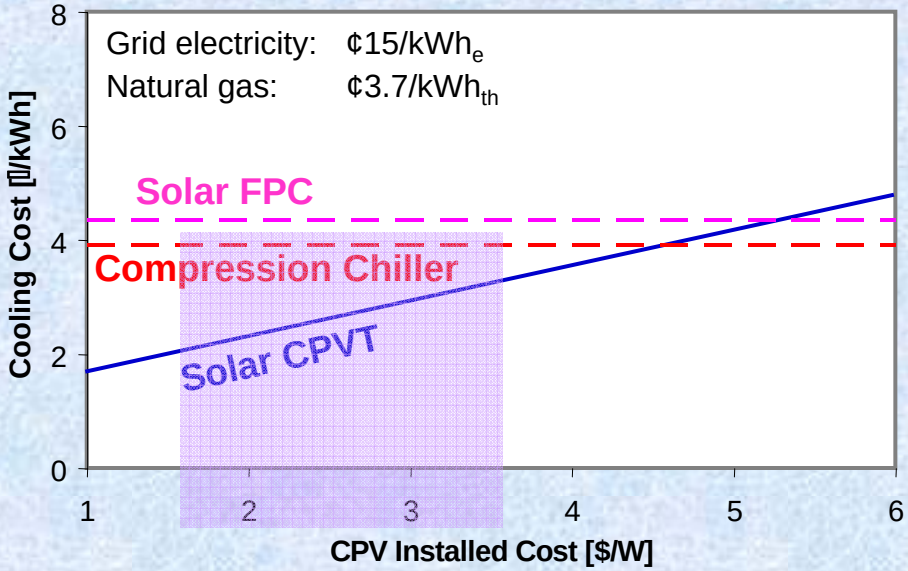
C = 50



C = 1,000

Results: Cost of Cooling





Conclusions

- **Concentration & Cogeneration**
  Significant **increase** in efficiency
  $\Rightarrow$ Competitive
  Medium temperature applications
  $\Rightarrow$ Wider market

- **Co-Generation with PV**
  seems better than
  co-generation with heat engines

- **Validation**