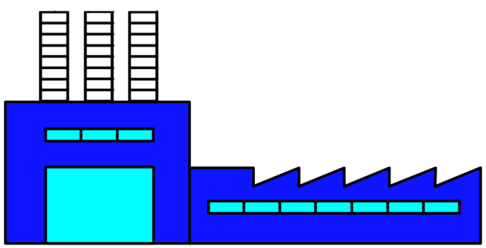
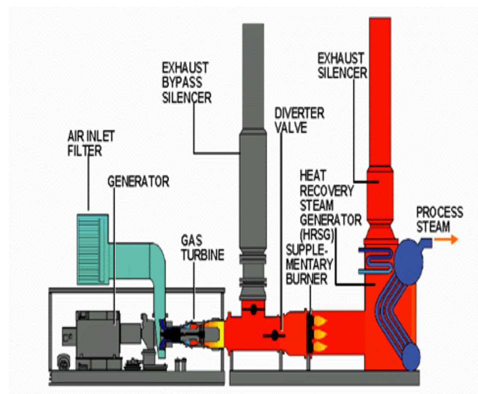
Cogeneration for Improving Energy Efficiency: Experience from Projects in Asia

Twinning project:
Improvement of energy efficiency in Turkey



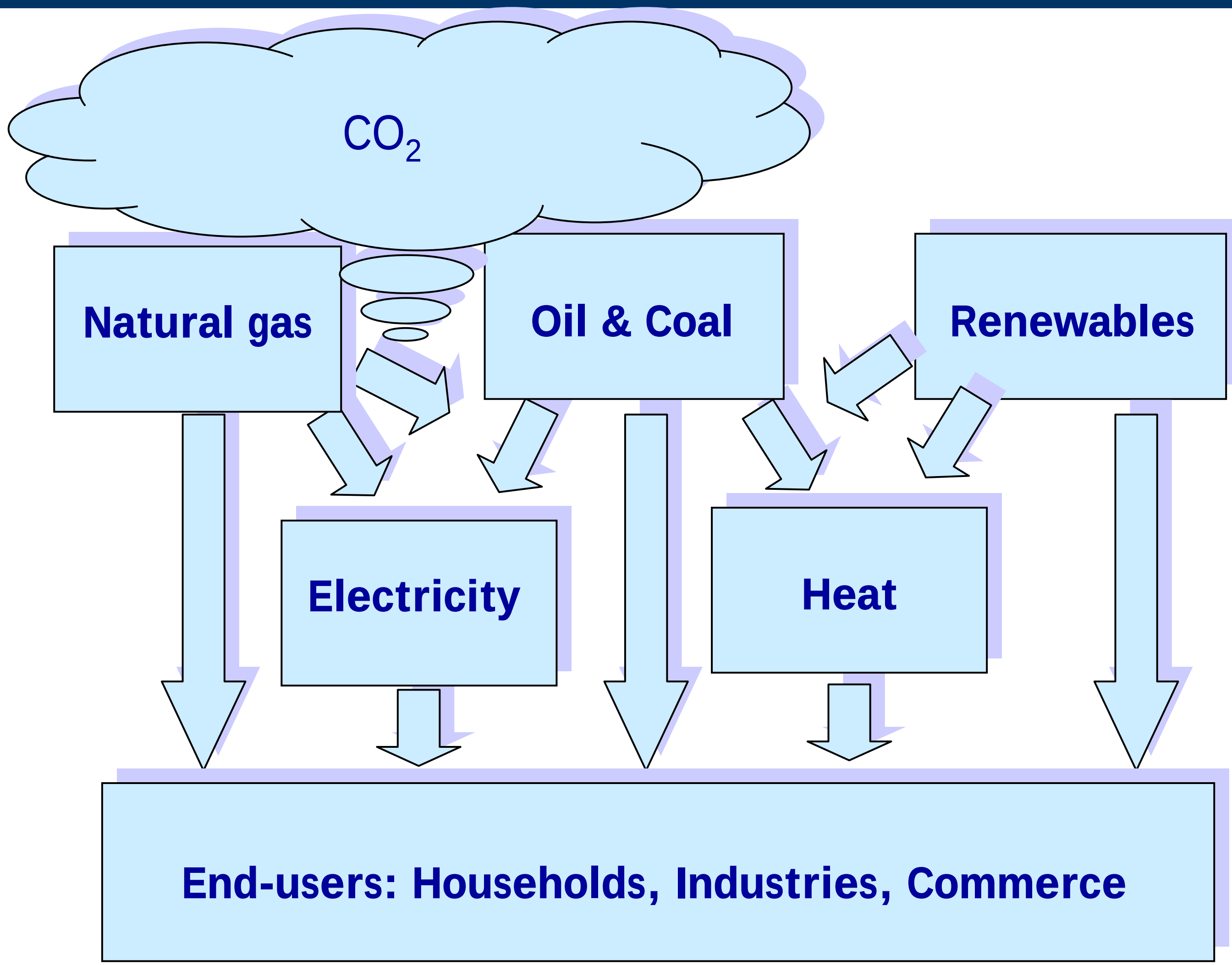


Brahmanand Mohanty, Ph.D.

Regional Adviser for Asia, French Agency for the Environment and Energy Management (ADEME)
Visiting Faculty, Asian Institute of Technology (AIT)

Ankara
08 June 2006

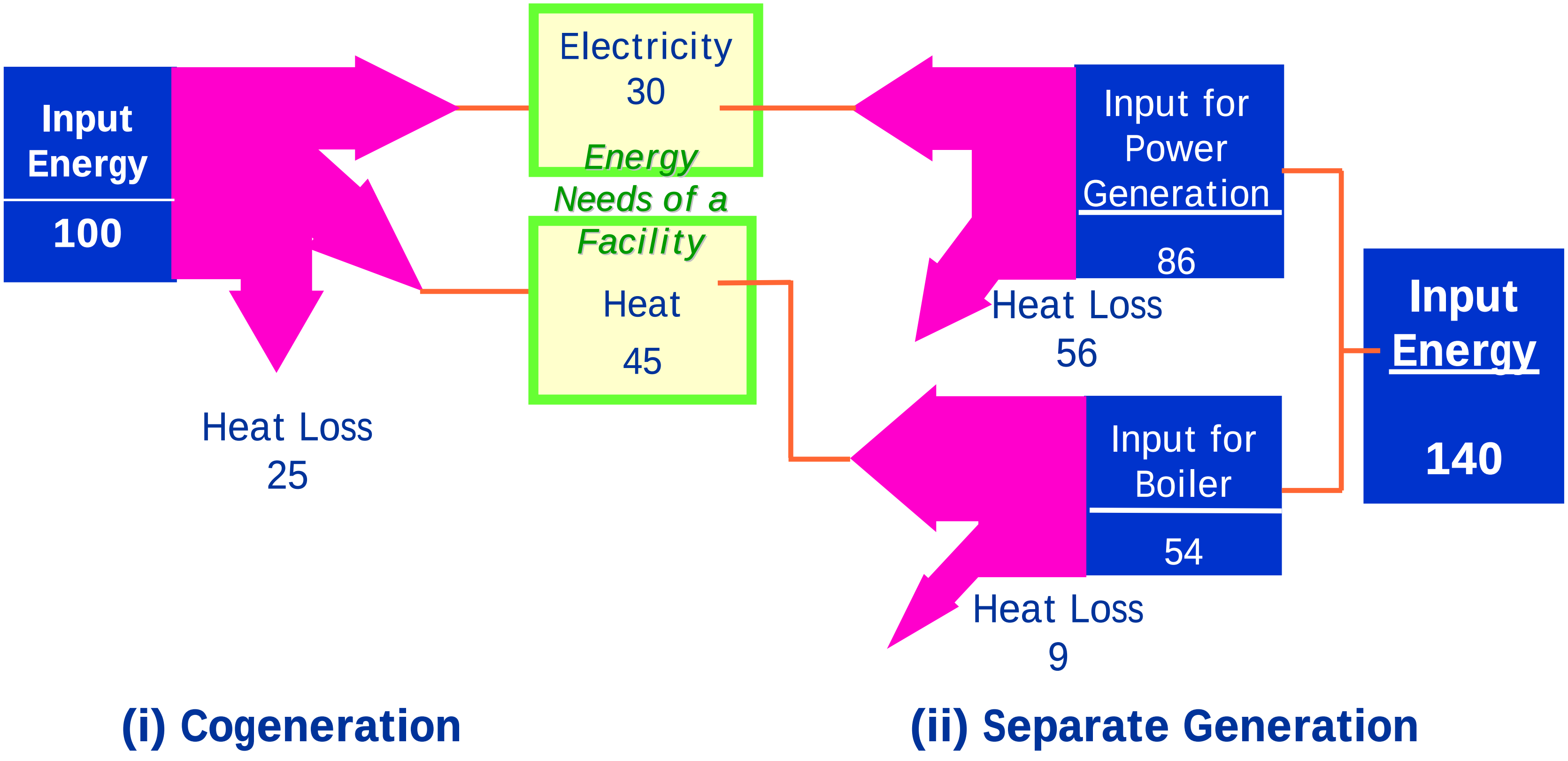
Energy supply for various end-uses



Pre-accession Assistance Programme
Improvement of Energy Efficiency in Turkey, Twinning Project: TR03-EY-01

Cogeneration: energy saving potential

- 40% potential for energy savings



Cogeneration: principal applications

Industry & Agriculture

District Heating

Buildings

Fuels for cogeneration

- Can use a variety of fuels
- Installation may be designed to handle more than one fuel

Available and forthcoming technologies

Steam Turbines

Gas Turbines

Combined Cycles

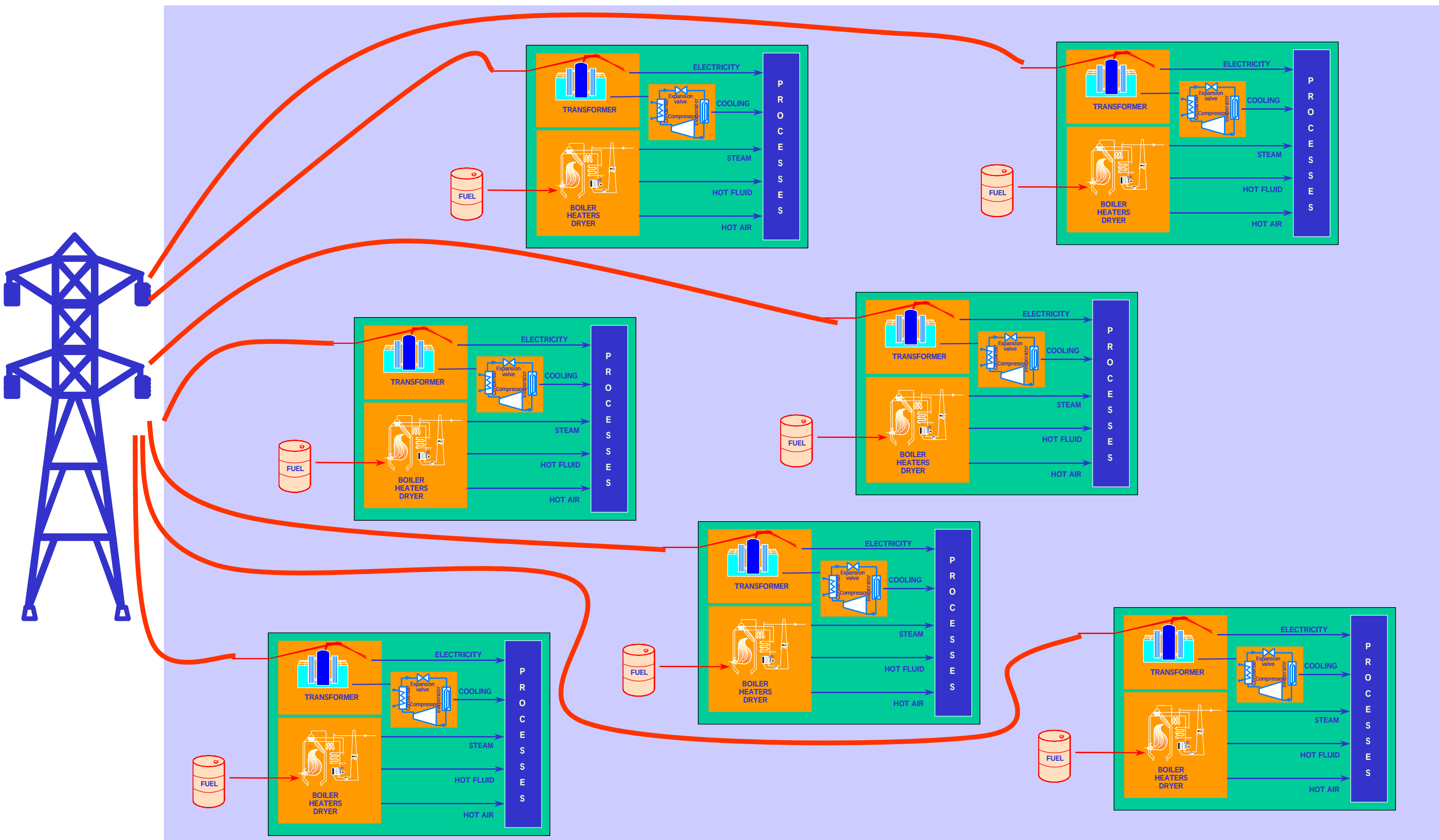
Engines (Diesel, Otto)

Micro turbines

Fuel Cells

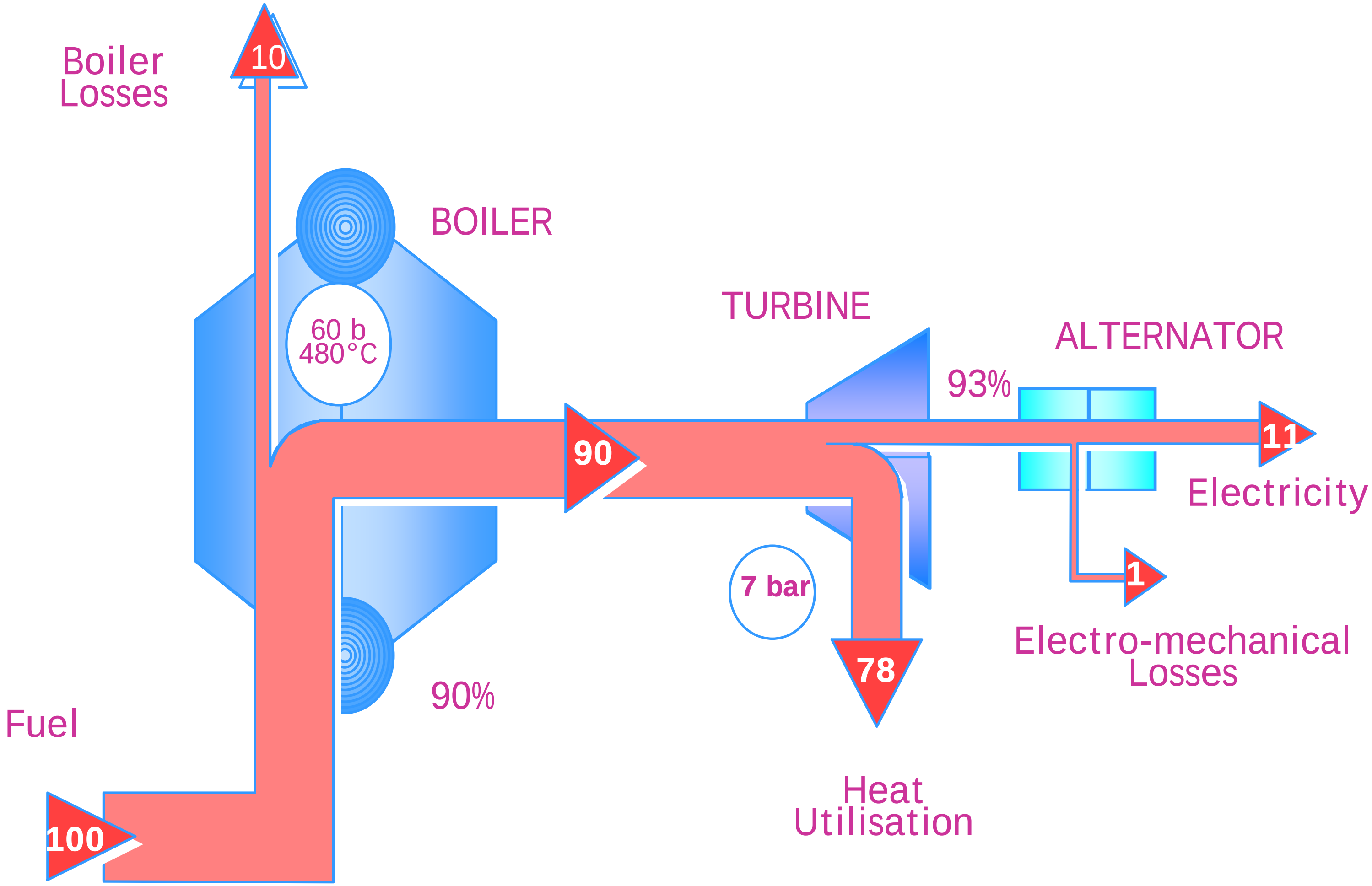
Stirling Engines

Energy supply in an industrial estate



Cogeneration & district energy network

From stand-alone boiler to cogeneration



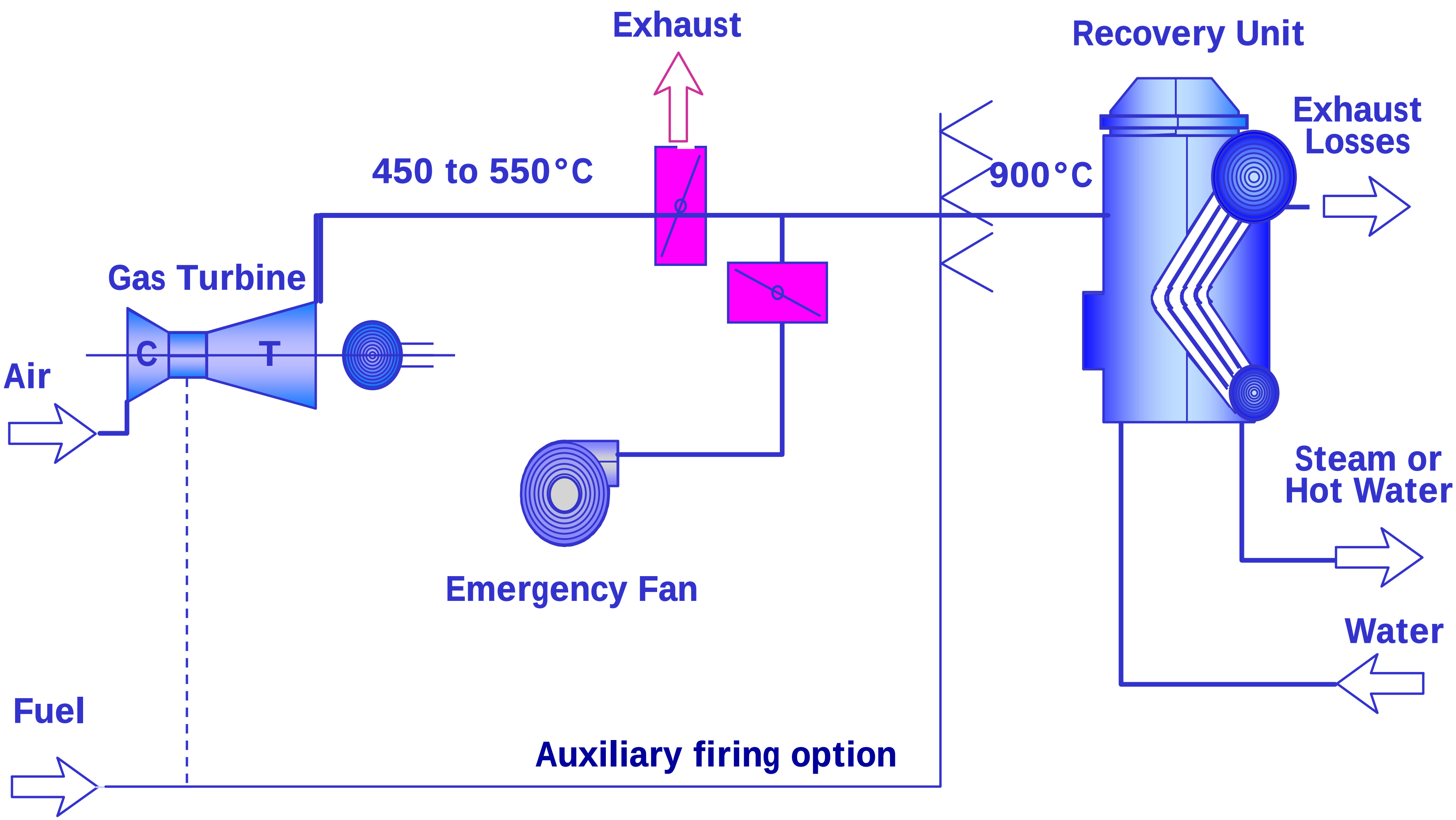
Use of back-pressure steam turbine

Natural gas spurring CHP growth

- Higher CHP growth with increased natural gas supply and long-term contractual LNG supply

- Best opportunities for future CHP technologies
  - Low investment risks (shorter payback periods in comparison with those for large scale power plants)
  - Reduced transmission and distribution losses
  - Potential for very high power efficiency (e.g. fuel cells)
  - Use of micro-CHP by individual users
  - Political back-up for CHP in most countries

Benefits of natural-gas fired cogeneration



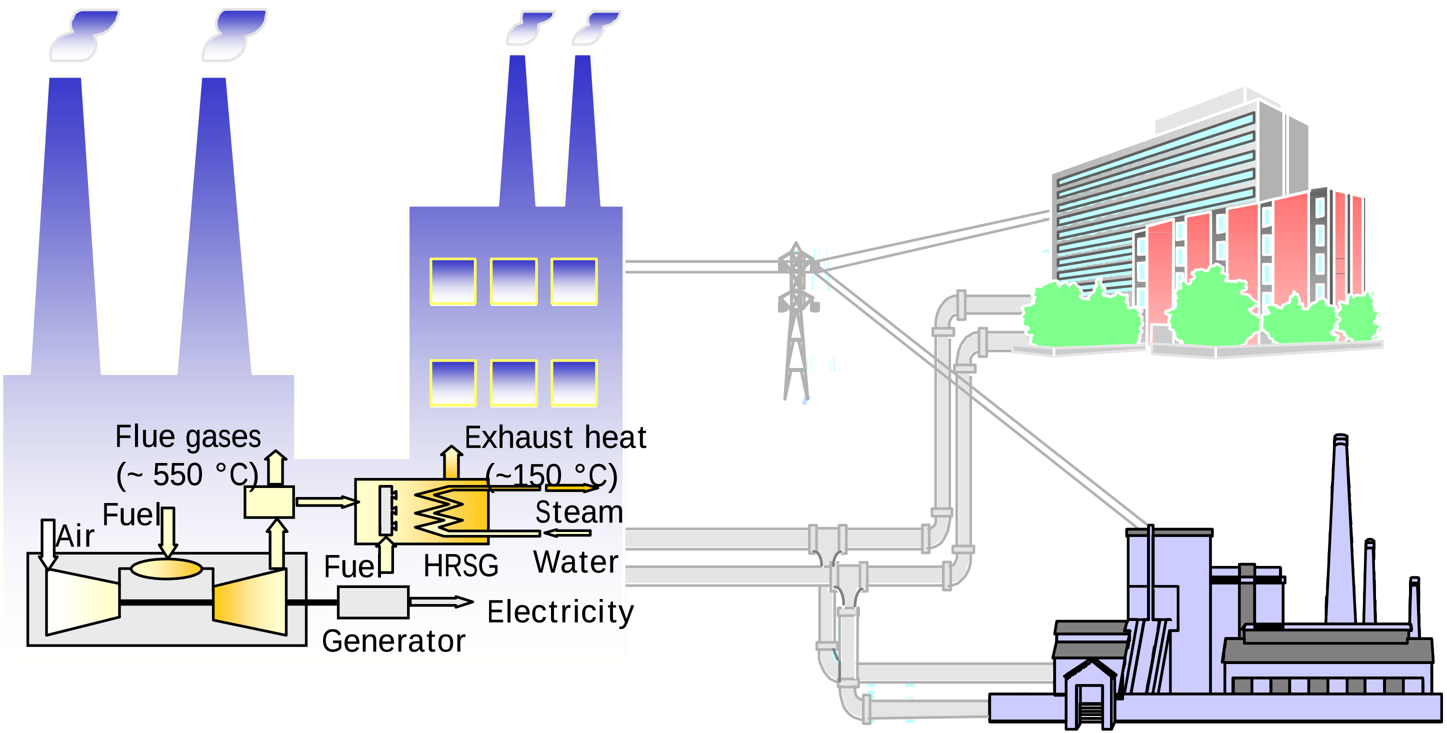
Gas turbines + heat recovery steam generator

Case study: Tabriz power plant (Iran)

- Existing power plant using steam boiler and condensing turbine
- Constraint
  - *Shortage of cooling water at the site*
- Scope for providing heat to a new city 15 km away through a district heating network
- Drawbacks:
  - *Low overall efficiency*
  - *High investment and high O&M costs, and*
  - *Line heat and pressure losses*

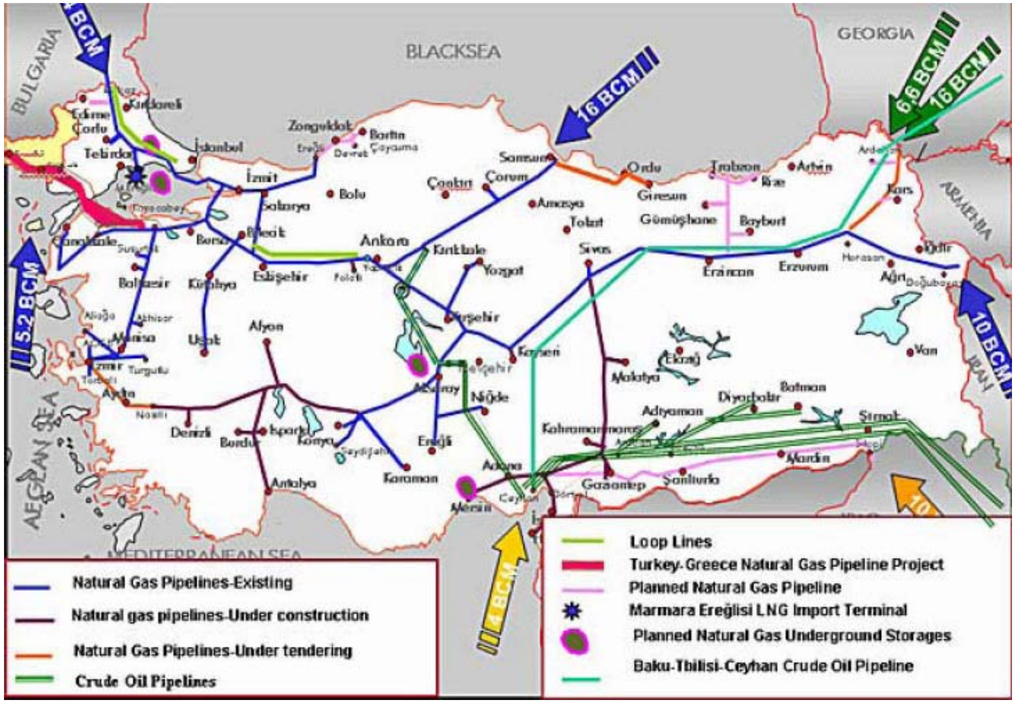
Tabriz: cogeneration & energy network

- Proposal: Installation of smaller gas turbines near the city
  - Heat recovered from gas turbines for the district heating network
  - Advantages: Higher overall efficiency, lower transmission and distribution losses, least environmental impacts



Cogeneration in Turkey

- Surrounded by oil and gas-rich countries (Azerbaijan, Iraq, Iran, Kazakhstan, Russia)
- Energy bridge between major oil producing Asian and Middle-East countries and Europe
- Over 2/3rd of energy are imported



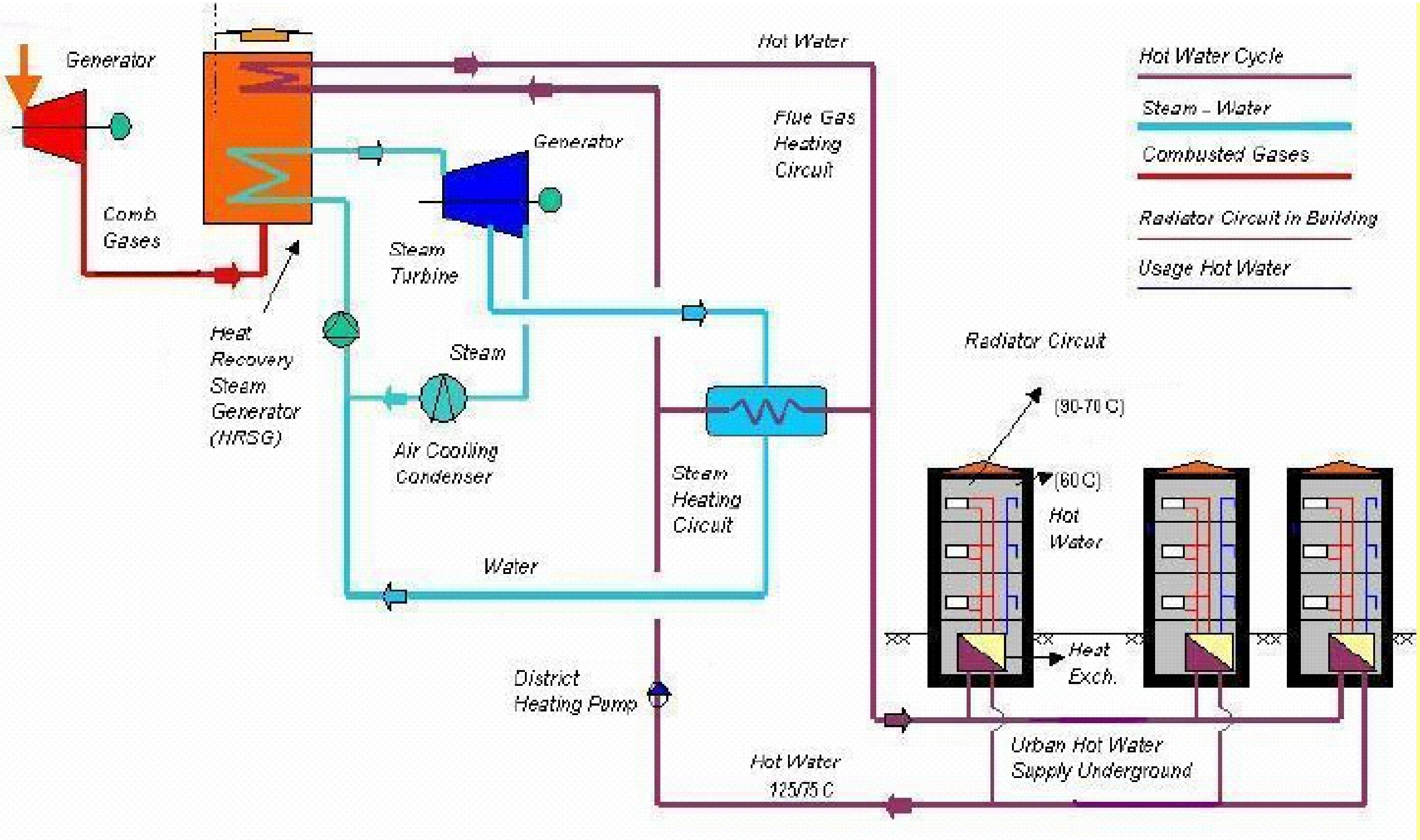
Cogeneration in Turkey

- First cogeneration application in a textile industry in 1992 (4MW capacity)
- By mid-2005, total installed cogeneration capacity increased to 4,700 MW
- The share of cogeneration in 2005 is 17.6% of the country's total power production (including combined cycle)
- Reasons for the rapid growth
  - High electricity tariff for industrial customers
  - Poor power quality and frequent interruptions due to shortage in electricity supply
  - Law allowing private sector to build, operate, transmit and distribute electricity
  - Government incentives (tax deduction, custom relief, etc.)
  - Access to natural gas grid
  - Competitive investment cost and high cycle efficiency
  - Short construction time, flexible operation and low operation & maintenance costs
  - Scope for setting up facilities close to high-heat users

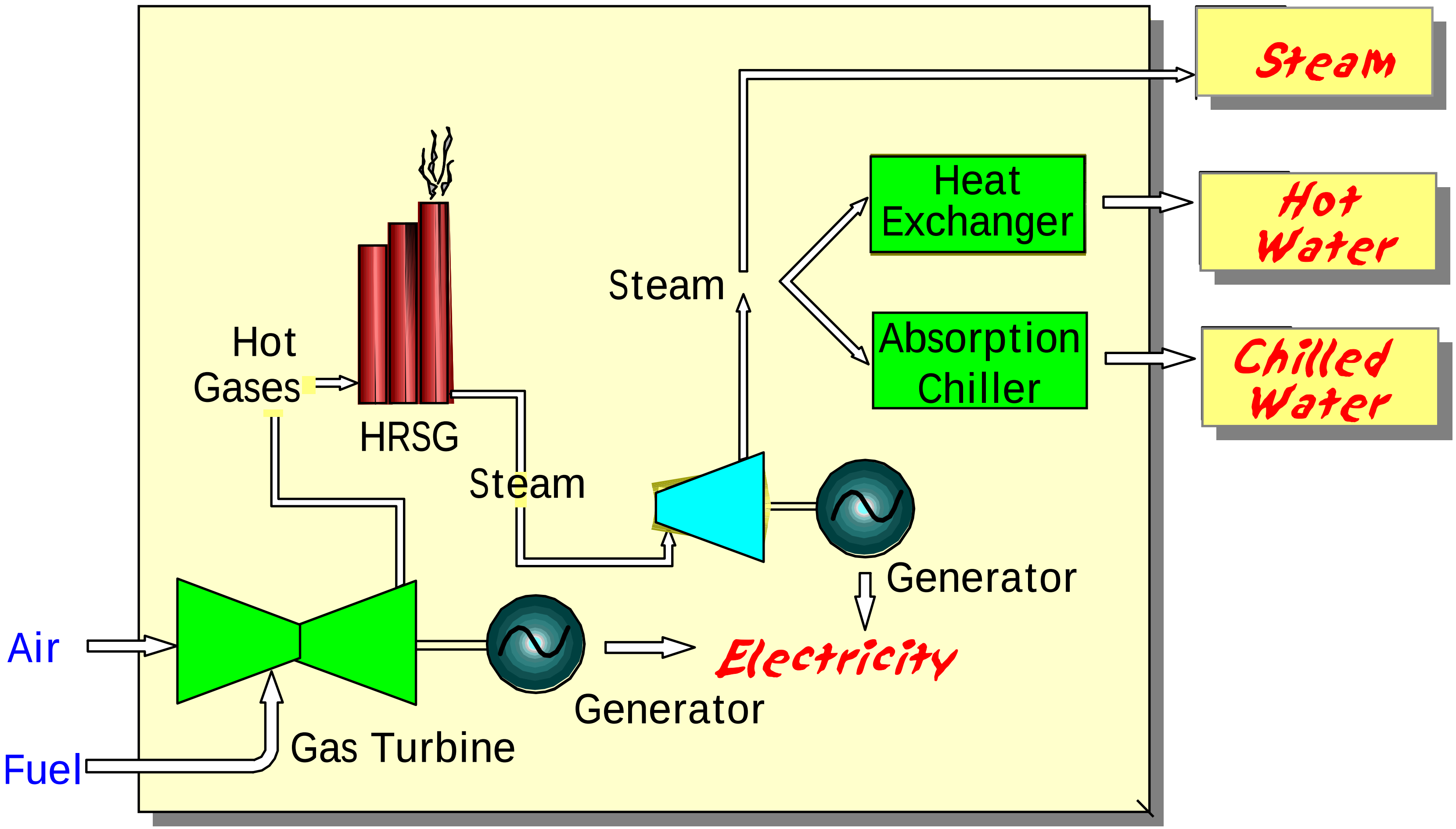
Cogeneration in Istanbul

- 350 MW of cogeneration (5% of the country’s total)
- Cogeneration adopted in industries (textile, automotive and white goods, paper, glass, wood) and mostly trigeneration in buildings (hospital, hotel, university, large residential building)
- First cogeneration plant of 180 MW capacity with district heating established in Istanbul in 1998
  - Connected to 14,000 new homes in Esenkent housing complex
  - Combined cycle cogeneration system
  - Electricity transmitted to national grid
  - Heat energy meeting the heating and hot water energy demand

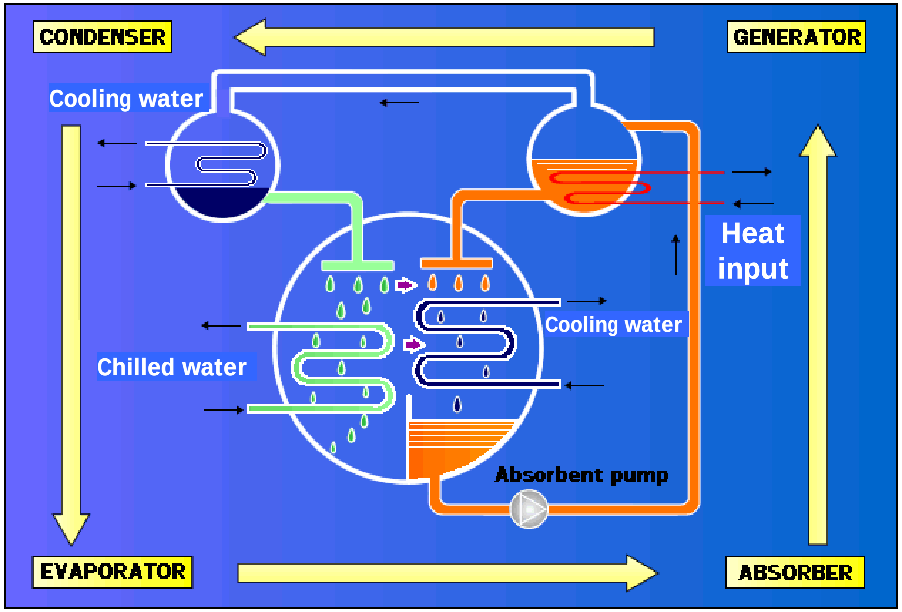
Esenyurt district heating system



Concept of trigeneration

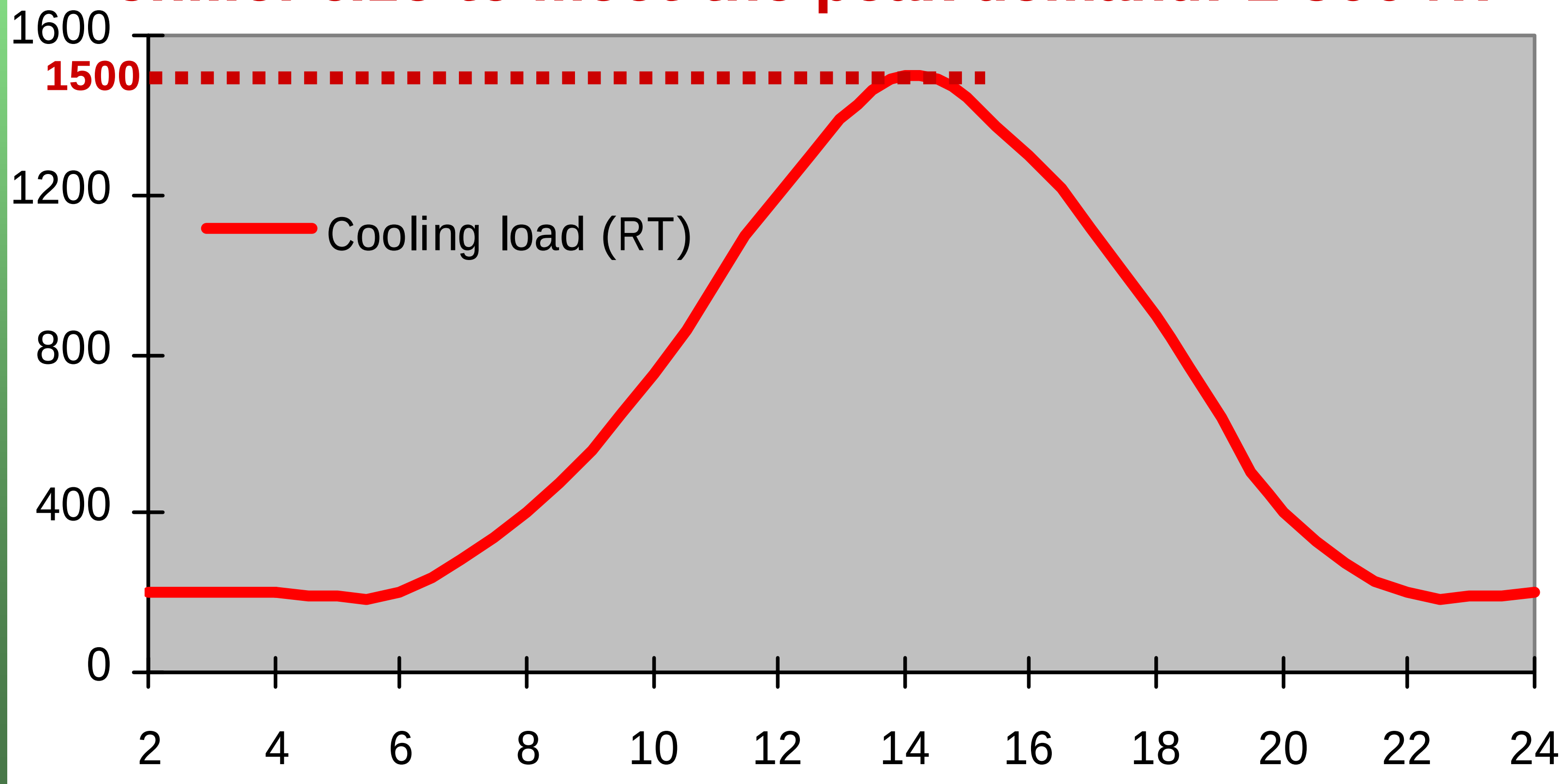


Vapour absorption cooling



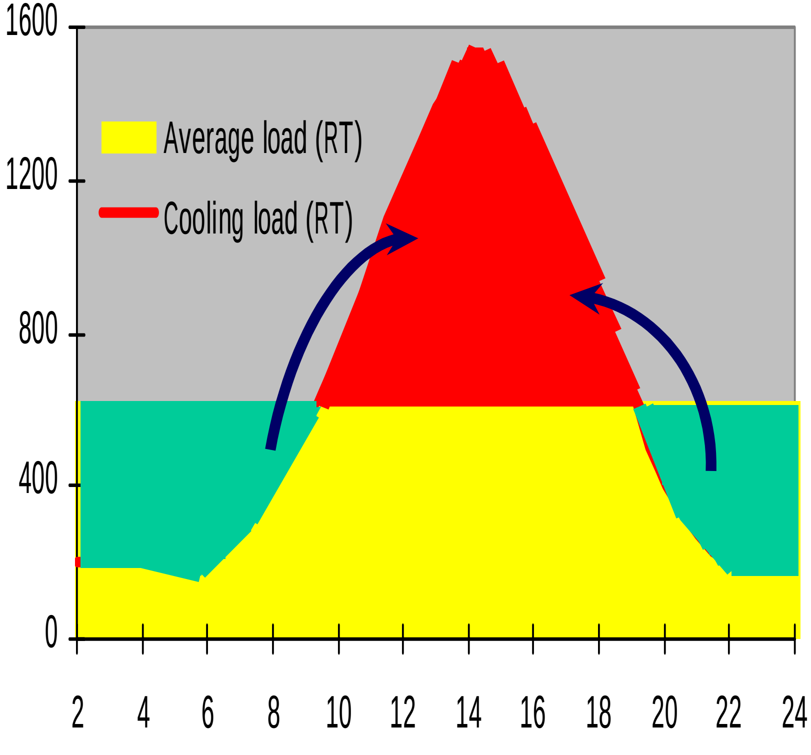
Thermal energy storage

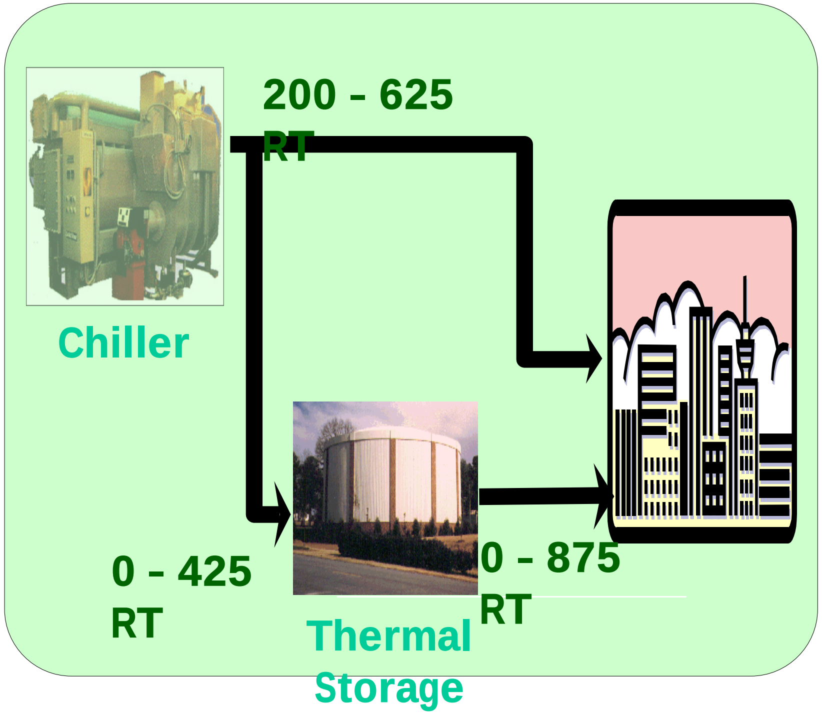
- **Peak cooling demand: 1 500 RT**
- **Chiller size to meet the peak demand: 1 500 RT**



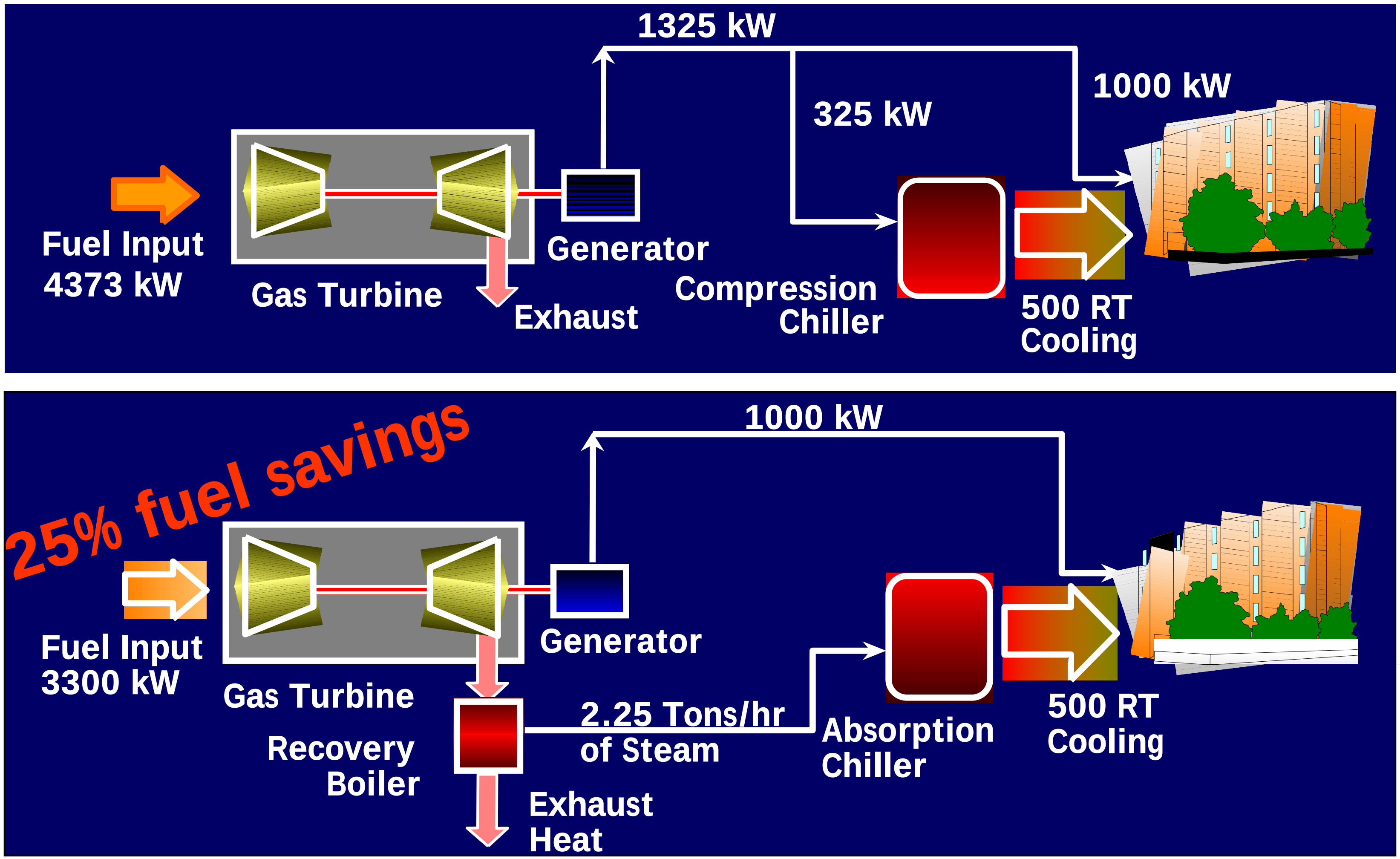
Thermal energy storage

- **Downsize the chiller size to 625 RT and install a cool thermal storage (continuous operation over 24 hours)**





Distributed cooling & power generation



KLCC district energy supply (Malaysia)

District cooling for over 600 000 m² of floor space in the KLCC North West Development area.

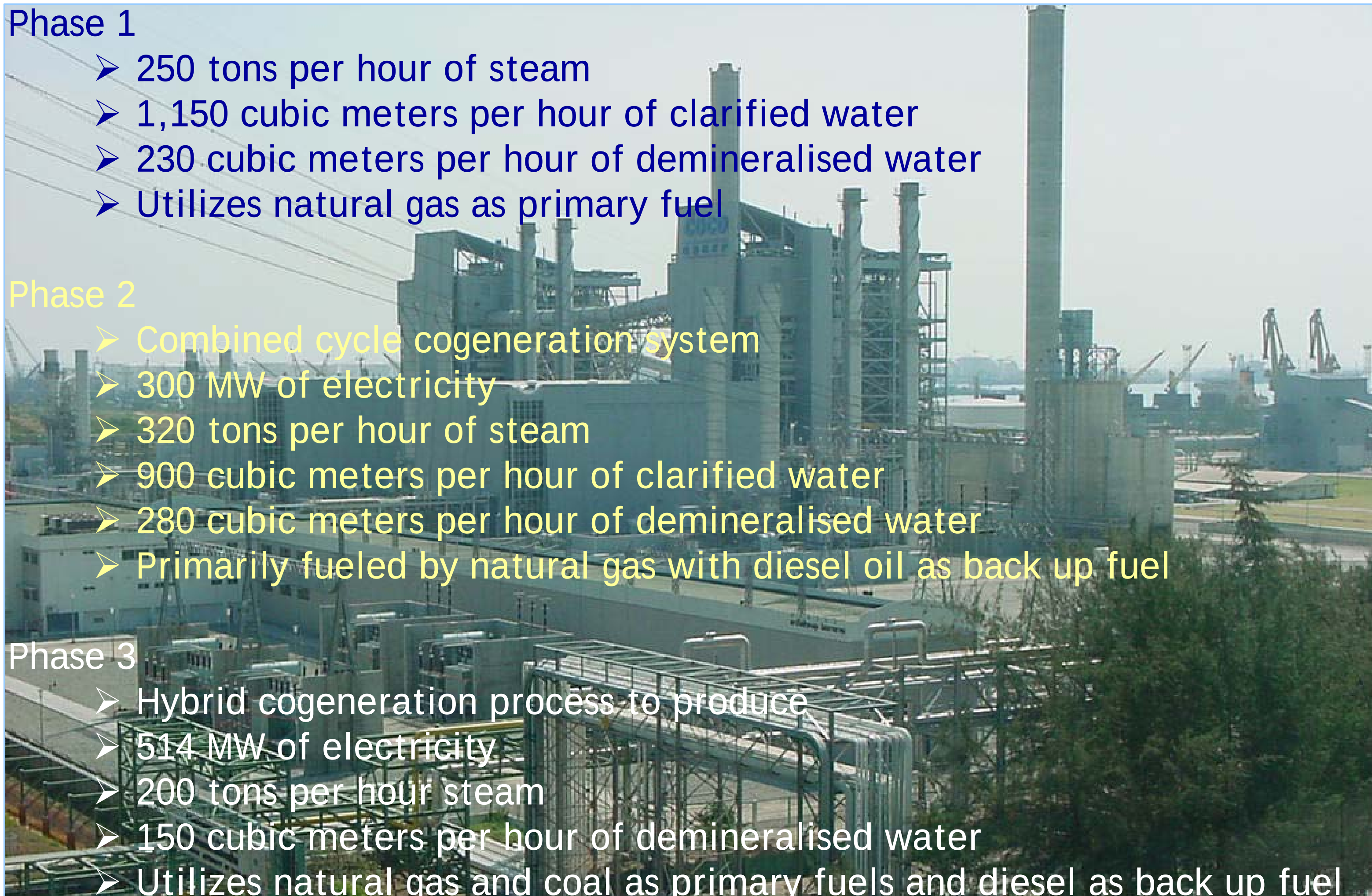
KLCC DG and district energy facility

- **2 gas turbine generators (each 50 MW)**
- **2 gas turbine generators (each 4 MW)**
- **2 heat recovery and gas fired steam generators (each ton/hr each)**
- **3 electrical centrifugal chillers (each 5000 RT)**
- **3 steam turbine driven centrifugal chillers (each 5000 RT)**

Map Tha Phut industrial cogeneration

- Cogeneration company created in October 1993
- 300 MW gas-fired combined cycle power plant
  - In 2 phases: 3 x 35 MW gas turbines with heat recovery steam generator + 1 x 50 MW steam turbine
  - Production in each phase: 150 MW electricity and 145 T/h steam (6 T/h at 52 Bar & 425°C; 85 T/h at 19 Bar & 250°C)
  - Sale of steam, electricity and demineralised water to industrial customers; sale of surplus power to utility grid
- Power generation efficiency
  - Combined cycle: 45.14%
  - Overall efficiency: 69.5%

Map Tha Phut distributed cogeneration



Phase 1

- 250 tons per hour of steam
- 1,150 cubic meters per hour of clarified water
- 230 cubic meters per hour of demineralised water
- Utilizes natural gas as primary fuel

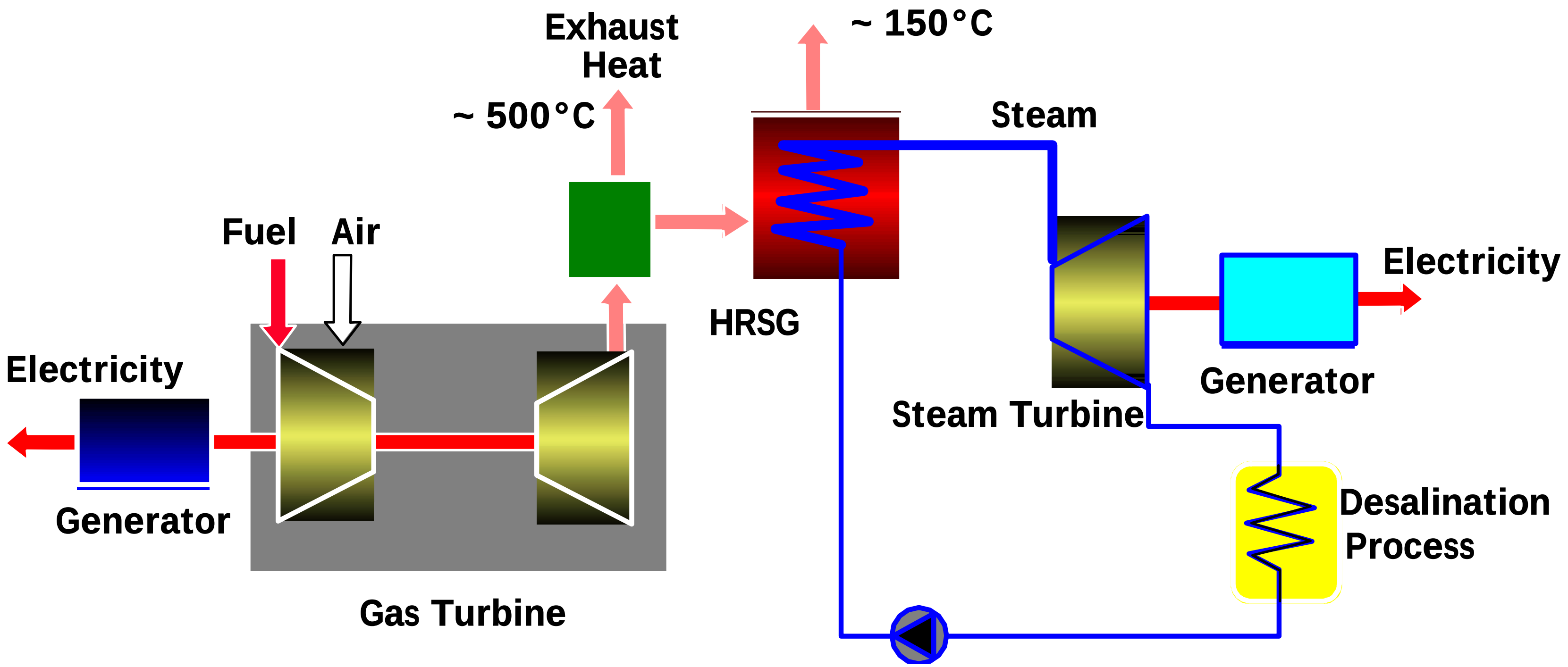
Phase 2

- Combined cycle cogeneration system
- 300 MW of electricity
- 320 tons per hour of steam
- 900 cubic meters per hour of clarified water
- 280 cubic meters per hour of demineralised water
- Primarily fueled by natural gas with diesel oil as back up fuel

Phase 3

- Hybrid cogeneration process to produce
- 514 MW of electricity
- 200 tons per hour steam
- 150 cubic meters per hour of demineralised water
- Utilizes natural gas and coal as primary fuels and diesel as back up fuel

Cogeneration proposal for Kish Island



Modification proposed:

Combined cycle cogeneration with back-pressure steam turbine, desalination using low pressure steam leaving the turbine

Cogeneration system in operation

2 HRSG using waste heat from gas turbine to produce 90 ton/h steam for sea water desalination.

Savings: 35 million litres of gas oil per year.

NO_x	182 tons
SO_2	550 tons
CO_2	92 680 tons
SO_3	8.4 tons
CO	0.1 tons
SPM	35 tons

Cogeneration system economics

Investment: 4 million euros
Savings: 35 million liter of gas oil per annum.

Cogeneration status in the ASEAN

Country	Present Situation	Installed Capacity (MW)*	Forecasted Annual Growth of Power Demand	Policy on Cogeneration	Key Off Taker
Cambodia	No National Grid	160	~10%	Preparing Phase	EDC
Indonesia	Gov.- 56% Captive Power – 40% IPP – 4%	23,425		IPP, Captive Power, Conservation	PLN
Malaysia	Gov – 85% Private – 15%	13,760	6-10%	SREP	TNB
Philippines	Gov – 55% Private – 45%	14,700	~9%	Renewable Energy	RECS& NPC
Singapore	Power Pool	8,140		-	EMA
Thailand	Gov – 60% Private – 40%	24,500	~10%	SPP (cogen 94-97, VSPP, RPS	EGAT
Vietnam	Gov – 90% Private – 10%	3,296	~13%	Preparing Phase	EVN

Cogeneration policy in the ASEAN

- Cogeneration policy differs from one country to another
- Cogeneration policy is part of national energy policy, but spread among various agencies
- Only Thailand has directly supported cogeneration through SPP (Small Power Program) through regulations on power purchase
  - Cogeneration and renewable
    - Cogeneration: efficiency > 45% and steam > 10%
  - Direct sale to industrial estates near the power plants
  - Sale to the transmission system at maximum 60 MW (90 MW on case by case basis)
  - Minimum energy purchase guarantee by power utility not less than 80% of the year

Cogeneration in Thailand (end 2003)

Type of SPPs	Exported to the grid	
	No.	MW
1. Cogeneration SPPs		
Natural Gas	19	1,413
Fuel Oil	1	9
Coal	4	196
Non-Conventional Fuels+Coal	3	190
Waste Gas	1	45
2. Renewable SPPs		
Non-Conventional Fuels (bagasse, rice husk, wood waste)	33	276
Total	61	2,129

Thailand cogeneration policy

Initiate a SPP-cogen program

1. Establish an analysis of the national potential for cogeneration
2. The analysis content:
•identify all potential for cogeneration
•identify the available fuels for cogeneration
•include a separate analysis of barriers preventing cogeneration - focus on barriers relating to the electricity prices, costs of fuels, access to fuels, grid issues, administrative procedures, financing of cogeneration plants and costs in energy prices
3. Set cogeneration target for renewable (biomass and biogas) and fossil (natural gas, coal and oil) energy – sub targets for industrial and cooling applications
4. Annually evaluate progress towards the cogeneration target – and calculate the energy savings and avoided "utility" investments due to cogeneration plants – and the energy losses from central plants
5. Annually evaluate progress towards the cogeneration target – and adjust the element in the programs
6. If required review existing RE (RPS and VSPP), energy efficiency and electricity programs according to this SPP-cogen program

Thailand cogeneration policy

SPP-cogen program – “incentive” options

1. CPS (Cogeneration Portfolio Standard)
2. Income tax holiday and accelerated depreciation
3. Regulated feed-in tariffs for electricity based on the retail prices – plus an energy premium payment depending on type of technology and fuel.

(CPS) should make it mandatory for new power plants developers to implement xx% cogeneration. The last two options should be given to individual developers implementing cogeneration plants on a voluntary and market basis.

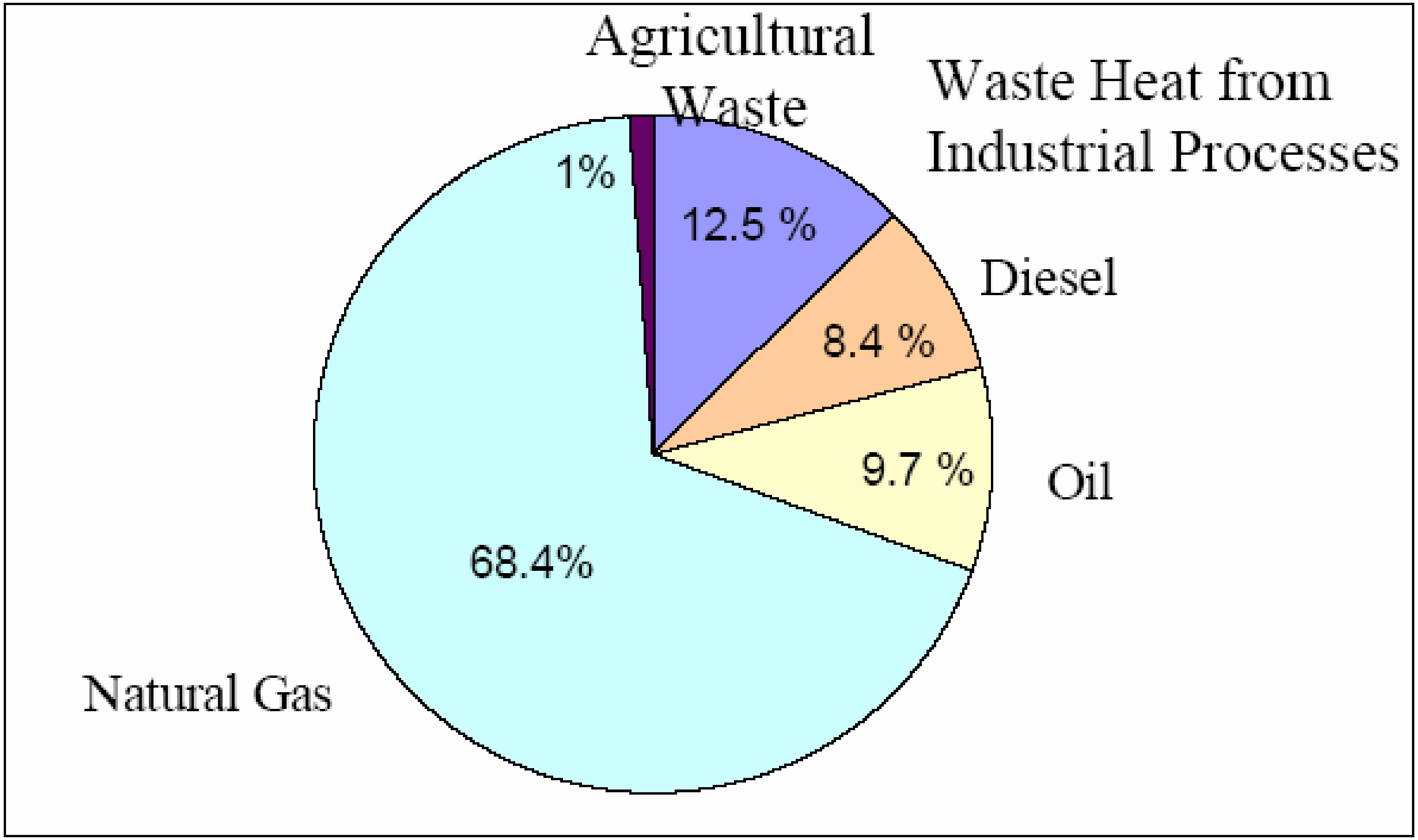
Cogeneration in Malaysia

Type	Area	Examples
Industrial Cogeneration	Pulp & paper, Palm oil, Cement, Steel, Glass, etc	Perwaja Steel, Shell Refining, Titan Petrochem. 350 palm oil mills
Fully Integrated Cogeneration	Large industrial complexes requiring heating, cooling & electricity	Petronas CUF, Proton City
District Cooling Cogeneration	Large commercial complex or high rise office buildings	KLIA, KLCC, KL Sentral, Tractors Malaysia

Cogeneration policy in Malaysia

- Cogeneration policy existed since a long time, but more could be done
- District cooling is in – due to tropical climate
- Licensing from Energy Commission – under purview of Ministry of Energy
- 36 licenses issued – 13 public, 23 private
- Cogeneration using renewable energy (including biomass and agro-industrial residues) is encouraged
- Large potential in palm oil industries

Cogeneration fuel mix in Malaysia



Pre-accession Assistance Programme
Improvement of Energy Efficiency in Turkey, Twinning Project: TR03-EY-01