Technology Fact Sheet for Mitigation
B. Combined Cycle Gas Turbines (CCGT) [i]

Sector: Energy	
Subsector: Power	
Technology characteristics	
Introduction	The principle is that the exhaust of one heat engine is used as the heat source for another, thus extracting more useful energy from the heat, increasing the system's overall efficiency.
Technology characteristics/highlights	• Well- established technology • A typical set would be a 270 MW gas turbine coupled to a 130 MW steam turbine giving 400 MW. • Larger units, have peak, steady state efficiencies of 55 - 59%.
Institutional and organizational requirements	EDL does not have the right people to operate these plants. As a result massive training programs and capacity building will be needed to ensure proper management and operation of the plant.
Operation and maintenance	• Operating such plants need experienced and expert people from different engineering backgrounds (Civil, Mechanical, Computer, Communication and Electrical). • Lebanon today has two CCGT plants with installed capacity exceeding 400 MW each, EDL does not have the technical capability to properly operate such plants. As a result EDL relies on specialized utilities and operation companies to manage the plants through what is called a O&M contract. • Training programs will be needed to hire and train local people to be then operating these plants. • It is worth noting that each CCGT requires between 200 and 250 employs of different levels.
Endorsement by experts	Recommended by experts due to its high efficiency.
Adequacy for current climate	• Gas turbines and heat recovery steam generators are very sensitive to site conditions such as the humidity, ambient temperature, sea water temperature…etc. • There is a significant drop in efficiency at higher temperatures reaching in some cases to reduction of 8 % in net efficiency. • This has a direct impact on the cost of generation by increasing the yearly fuel bill. This cost is estimated to be a significant number. • For the case of the CCGT's in Lebanon and taking the average fuel cost in Lebanon a deterioration of 1%pts in efficiency add up to a USD 2 million to the fuel bill on a yearly basis.
Scale/Size of beneficiaries group	The whole power sector will benefit from loss reduction, mainly EDL.
Disadvantages	Disadvantages are relative and are very project specific. Below are some • Existing units in Beddawi and Zahrani are driven by DO combustion, making them more polluting and less economic.

	• A major disadvantage of CCGT's is the need for large quantities of pure/sea water, which renders the project not feasible if not to be on the coastal line. • There are so many moving parts in the plant; rotational speed of turbines exceeds 3,000 rpm which requires a delicate maintenance to maintain the availability and the lifetime of the plant. • The plant needs a lot of auxiliary equipment's that are big, capital extensive and energy consuming. For example the desalination plant, demineralization plant, fuel treatment plants and big water pumps.
Capital costs	
Cost to implement mitigation technology	• The cost varies between USD800 and 1,200 per each installed kW. It depends on the project and its mode of operation. • Based on research conducted by MOEW the costs of production are as follows: CCGT @ NG is 8.63 ¢/kWh CCGT @ HFO is 13 ¢/kWh CCGT @ DO is 19 ¢/kWh
Additional cost implement mitigation technology, compared to "business as usual"	• Depends on the type of fuel used. It is given that today the average cost of production in Lebanon is ~18.5 ¢/kWh. • If the plant is constructed to operate on either NG or HFO, there will be no additional cost. • But if designed to burn DO then the additional cost is about 0.5 ¢ per each kWh produced. • A plant that produces 3,000 GWh a year the additional cost is ~USD 15 million.
Development impacts, direct and indirect benefits	
Direct benefits	• No additional costs for NG and HFO. • Higher efficiency. • GHG emissions reduction
Reduction of vulnerability to climate change, indirect	CCGT will assist in fuel diversification, and has no negative impacts as long as climate change is concerned.
Economic benefits, indirect Employment Growth & Investment	• The value of loss of load is around USD1,600 /MWh. Thus the additional produced energy satisfies the economy by reducing the losses due to unsupplied energy. • Cost of Private Generation: since the Lebanese community invests a lot in private generation thus additional supply will remove the burden of private generation.
Social benefits, indirect	Capacity building initiatives and training programs will be needed.
Environmental benefits, indirect	Reduced GHG emissions due to improved efficiency.
Local context	
Opportunities and Barriers	• Availability of natural gas. • Securing the finance to cover the capital cost may be difficult

	task for EDL or MOEW. • Huge infrastructure for the gas pipeline.
Market potential	Not Available. CCGT is a large scale, non-market technology.
Status	The technology has been adopted for base load generation and for future expansion.
Timeframe	Medium term
Acceptability to local stakeholders	• CCGT is considered as an economically feasible option for generation expansion and GHG mitigation. • NG availability will also lead to its penetration into the industrial sector.

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Mitigation – Lebanon. You can access the complete report from the TNA project website http://tech-action.org/**