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Steps Towards Energy Recovery in the Hashemite Kingdom of Jordan

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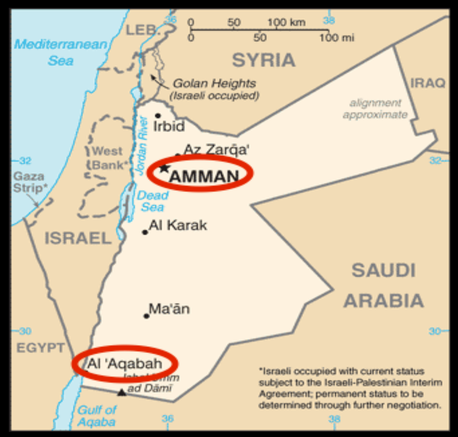
Introduction

The Kingdom of Jordan relies almost entirely on imported foreign energy. Syria and Egypt were major suppliers of crude oil products and natural gas respectively. Due to recent the turmoil the Kingdom has therefore had to consider other ways of sourcing energy to meet its energy needs. In recent years with the occurrence of the Arab Spring, and inner turmoil in Syria and Iraq, there has been a large inflow of refugees and foreign nationals, into the Kingdom. As a whole Jordan is now 70% Jordanian and 30% foreign nationals. The consequence of a fast growing population means the Kingdom will have to deal with the ever-increasing production of waste. The focus of the research was to investigate the potential to divert this increased waste to provide a stable local energy source for the Kingdom.

Methodology and Approach

The research involved a three-phased approach to gathering information about waste management in developing countries, and in particular Jordan, technologies for energy and resource recovery: (i) a detailed literature review; (ii) a field study investigation in Jordan focusing on waste management practice in two selected cities, Amman, the Kingdom's capital and Aqaba, the only coastal city in Jordan; (iii) discussions with key representatives from the waste and energy sectors in the UK. Use is made of (i) the Wasteaware Indicator methodology developed by Wilson et al (2015) (a qualitative analysis) to assess the waste management in Jordan and (ii) a methodology developed by Grimes and Tanpoonkiat (2013) to aid planning decisions on the optimum technology mix to deliver an integrated solid waste management system that treats waste as a resource to deliver energy for the Kingdom.



Technology Mix Analysis

Assumptions of Analysis

Growth Scenario	Growth Rate
Low Growth	2.5%
Normal Growth	3.1%
High Growth	5.3%

Technology Capacities and Costs

Technology	Plant Capacity (tonnes per annum)	Cost (GBP/tonne)
Incineration	400,000	1000
Gasification	60,000	1100 (+ 500 for pretreatment)
AD	45,000	500

Technology Mix Results Amman

Ratio	% Growth	2025 (50MW Scenario) Number of Plants				2060 (Full Diversion Scenario) Number of Plants		
		I or G	AD	% Diverted		I or G	AD	
1:0	2.5	2	13	0	58	8	50	0
1:0	3.1	2	13	0	54	10	66	0
1:0	5.3	2	13	0	43	26	173	0
80:20	2.5	2	10	4	58	6	40	14
80:20	3.1	2	10	4	54	8	53	18
80:20	5.3	2	10	4	43	21	138	46
50:50	2.5	1	6	9	58	4	25	34
50:50	3.1	1	6	9	54	5	33	44
50:50	5.3	1	6	9	43	13	87	115
20:80	2.5	1	3	13	58	2	10	54
20:80	3.1	1	3	13	54	2	13	70
20:80	5.3	1	3	13	43	6	35	184

Technology Mix Results Aqaba

Ratio	% Growth	2025 (Full Diversion Scenario) Number of Plants		2060 (Full Diversion Scenario) Number of Plants	
		G	AD	G	AD
1:0	2.5	2	0	3	0
1:0	3.1	2	0	4	0
1:0	5.3	2	0	10	0
0:1	2.5	0	2	0	4
0:1	3.1	0	2	0	5
0:1	5.3	0	2	0	13
50:50	2.5	1	1	2	2
50:50	3.1	1	1	2	3
50:50	5.3	1	1	5	7

WasteAware Assessments

Background information on the city						
City		Amman				
Country		Jordan				
Date since previous application of indicators:		N/A				
B1	Country income category	World Bank income category	Gross National Income (GNI) per capita			
		Upper Middle	$5160			
B2	Population of city	Total population of the city	4,007,526			
B3	Waste generation	Total municipal solid waste generation (tonnes/year)	967265			
No	**Category**	**Data/ Benchmark Indicator**	**Results**	**Code**		**Progress**
Key Waste-related data		***Data***		-	-	-
W1	Waste per capita	MSW per capita kg per year	241.36	-	-	
		MSW per capita kg per day	0.661	-	-	
W2	Waste composition:	Summary composition of MSW for 3 key fractions – all as % wt. of total waste generated	-	-	-	-
W2.1	Organic	Organics (food and green wastes) %	49.7	-	-	-
W2.2	Paper	Paper %	14.7	-	-	-
W2.3	Plastics	Plastics %	15.7	-	-	-
W2.4	Metals	Metals %	1.4	-	-	-
W2.5	Solid waste density	Solid waste density	-	-	-	-
W2.6	Moisture content	Moisture content	40.03	-	-	-
Physical Components		***Benchmark Indicator***	-	-	-	-
1	Public health – waste collection	1.1 Waste collection coverage	95			
		1.2 Waste Captured by the System	93			
1C		Quality of waste collection service	38			
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	100			
2E		Quality of environmental protection of waste treatment and disposal	55			
3	Resource Management – Reduce, Reuse, Recycle	Recycling rate	7			
3R		Quality of 3Rs – Reduce, reuse, recycle	13			
Governance Factors		***Benchmark Indicator***	-	-	-	-
4U	Inclusivity	User inclusivity	38			
4P		Provider inclusivity	30			
5F	Financial sustainability	Financial sustainability	75			
6N	Sound institutions, proactive policies	Adequacy of national solid waste management framework	17			
6L		Local institutional coherence	50			

Background information on the city						
City		Aqaba				
Country		Jordan				
Date since previous application of indicators:						
B1	Country income category	World Bank income category	Gross National Income (GNI) per capita			
			$5160			
B2	Population of city	Total population of the city	188,160			
B3	Waste generation	Total municipal solid waste generation (tonnes/year)	50079			
No	**Category**	**Data/ Benchmark Indicator**	**Results**	**Code**		**Progress**
Key Waste-related data		***Data***		-	-	-
W1	Waste per capita	MSW per capita kg per year	0	-	-	
		MSW per capita kg per day	1	-	-	
W2	Waste composition:	Summary composition of MSW for 3 key fractions – all as % wt. of total waste generated	-	-	-	-
W2.1	Organic	Organics (food and green wastes) %	55	-	-	-
W2.2	Paper	Paper %	15	-	-	-
W2.3	Plastics	Plastics %	16	-	-	-
W2.4	Metals	Metals %	8	-	-	-
W2.5	Solid waste density	Solid waste density	0	-	-	-
W2.6	Moisture content	Moisture content	0	-	-	-
Physical Components		***Benchmark Indicator***	-	-	-	-
1	Public health – waste collection	1.1 Waste collection coverage	100			
		1.2 Waste Captured by the System	100			
1C		Quality of waste collection service	79			
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	100			
2E		Quality of environmental protection of waste treatment and disposal	25			
3	Resource Management – Reduce, Reuse, Recycle	Recycling rate	30			
3R		Quality of 3Rs – Reduce, reuse, recycle	33			
Governance Factors		***Benchmark Indicator***	-	-	-	-
4U	Inclusivity	User inclusivity	42			
4P		Provider inclusivity	45			
5F	Financial sustainability	Financial sustainability	58			
6N	Sound institutions, proactive policies	Adequacy of national solid waste management framework	0			
6L		Local institutional coherence	50			

Summary

•The Kingdom of Jordan has relied on foreign supplies of energy. In recent years these supplies have decreased while the population has increased and security of supply of energy to the country is threatened.
•An in-field investigation of two key cities in the Kingdom, Amman and Aqaba, has shown the scope for improvement in enforcement at the local and national level and, in management of waste as a resource for material and energy recovery
•Analysis of the cities' scope to convert waste to energy has shown that in Amman, in particular, waste can be exploited to provide steady and secure supply of energy locally
•A technology mix analysis has shown that in Amman, incineration can be used to treat waste and produce 50MW of electricity by 2025, and in Aqaba, gasification, which can be operated at a smaller scale can be used to treat waste producing energy to meet needs of the city by 2025.

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