Are Energy Efficiency Improvements Always the Most Cost-Effective Investments?

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ABSTRACT

The United Nations Industrial Development Organization (UNIDO) implemented the Mediterranean Transfer of Environmentally Sound Technology (MED/TEST) Phase II in the Southern Mediterranean Region between 2016 and 2018. This paper reports the findings of resource efficiency demonstrations with 58 companies in three North African countries (Algeria, Morocco, and Tunisia). The paper draws on the findings of Material Flow Cost Accounting that estimates the full costs of energy, water and rawmaterials used in production processes, and of Resource Efficiency and Cleaner Production Assessments that identify feasible and cost-effective interventions. The combination of these two tools allows for a comparison of the payback periods of a full range of potential resource efficiencymeasures.Not surprisingly, there are severalwater and raw materials measuresthat havereturns on investment similar to those for energymeasures.

Keywords: Energy efficiency, Water Efficiency, Raw Materials Efficiency, Industry, North Africa

NONMENCLATURE

Abbreviations	
APEN	Applied Energy
Symbols	
n	Year 2021

1. INTRODUCTION

The United Nations Industrial Development Organization (UNIDO) implemented the Mediterranean Transfer of Environmentally Sound Technology (MEDTEST) Phase II in the Southern Mediterranean Region (eight countries) between 2016 and 2018. This paper analyzes the findings of resource efficiency demonstration projects with 58 companies in the three North African countries (Algeria, Morocco, and Tunisia) [1].

The aim of this paper is four-fold. First is to briefly describe the three management systems that constitute the Transfer of Environmentally Sound (TEST) approach. Second is to describe the resource savings and emission reductions identified by the MED TEST project.Third is to show the extent to which energy efficiencymeasuresconstitute a significant number of resource efficiency measures, cost savings, and investments in the 58 companies.Fourth is to show that there are water and raw materialsmeasures with payback periods (PBPs)similar to those for energy measures.

2. MATERIALS AND METHODS

The TEST approach is a systematic way of identifying and exploiting the most feasible potentials for resource efficiency and continuous improvement in the use of raw materials, water, and energy within a company. It combines the essential elements of a set of tools for sustainable production, namely, Material Flow Cost Accounting (MFCA), Resource Efficient and Cleaner Production Assessments (RECPA), and environmental and energy management systems (EMS/EnMS).

MFCAreveals the full costs of production, including environmental costs like non-product outputs. Itestablishes an ad hocinformation system for the important materials, water and energy flows and key processes. This is essential for monitoring major losses and consumption of resources. RECPA is at the core of the TEST approach. It is a step-by-step assessment for improving the resource efficiency and environmental performance of production systems. The output of this tool is a portfolio of financially feasible solutions, including good housekeeping, operational control improvements, process and product modifications, and eco-innovative technologies. The TEST approach usesEMS and EnMS to integrate resource efficiency into the company's overall management systems. They ensure that resource efficiency programs are implemented, sustained, and further developed by companies.

three country summary reports[2, 3 and 4] and 58 standardized company reports prepared by that have MED TEST teams in Algeria, Tunisia, and Morocco. The company dataarestoredin UNIDO's Industrial Resource Efficiency Division's databases and available upon request to the authors.

4. RESULTS

4.1 Overview and Demonstration Findings

In Algeria, 12 companies from the food and beverage sector participated in the demonstration phase of MED TEST II [2]. The companies range in size from SMEs with 150 full-time employees to large companies with 500 employees. Out of all resource efficiency measures identified by the TEST team, 87% of the total were incorporated into company action plans [1]. ThePBPs of 50% of the measures are less than or equal to 0.5 years,

Table 1: Resource Savings and Emission Reductions

Country	Energy Savings (GWh/year)	CO_2 Emission Reductions (t/year)	Water Savings (m^3/year)	Solid Waste Reductions (t/year)	Material Savings (t/year)	Chemical Oxygen Demand (t/year)
Algeria	29.8	18,800	435,000	820	14,500	520
Morocco	97.6	39,500	131,500	3,200	5,200	160
Tunisia	111.2	35,200	449,000	2,400	7,100	30

Sources: [1,2,3, and 4]

This paper adds to the limited literature on applications of MFCA and onRECP projects in the North African region.We found one article about the application of MFCA in the first TEST project, implemented in the Danube region [5], and a second article about the limited integration of MFCA into company accounting practices in Europe [6]. We found only two articles on the implementation of resource efficiency projects in the North African region. One describes the application of Cleaner Production in Egypt [7] and the other describes renewable energy and energy efficiency efforts in Tunisia [8].

3. CALCULATIONS

The data forthis paper are based on the application of two of the three analytical tools of the TEST methodology: MFCA and RECPA. We took data from

15% are between 0.5 and to 1.5 years, 13% are between 1.5 and 3.0 years, and 22% are greater than 3 years.With an investment of 3.29 million euros, the 12 companies could save 2.67 million euros annually. [1]. Themeasuresidentified by the MED TEST teamwould result inresource savings and emission reduction described in Table 1.In Morocco, 20 companies from the food and beverage,mechanical, and textile sectors participated in thedemonstration phase of MED TEST II [3]. The companiesrange in size from SMEs with 50 full-time employees to large companies with 400 employees. Out of all resource efficiency measures identified by the TEST team, 86% were incorporated into company action plans. The PBPs of 36% of the measures are less than or equal to 0.5 years, 21% are between 0.5and 1.5 years, 17% are between 1.5 and 3 years and 26 % are greater than 3 years. With an investment of 21.5 million euros, these companies

could save 10.4 million euros annually [1]. The measures identified by the MED TEST team wouldresult in significant resource savings and emission reductions described in Table 1.

- Energy savings are 24% of total savings; and
- The average payback period for all energymeasures for all companies is 0.7 years.

Table 2: Energy Measures

Country	Total Number of Measures	Energy Measures (% of (total)	Total Investment (10^6Euro)	Energy Investment (% of total)	Total Annual Savings (10^6 Euro)	Annual Energy Savings (% of Savings)	AverageEnergyPaybackPeriods(years)
Algeria	205	38	5.1	14	4.4	24	0.7
Morocco	449	43	25.1	69	11.2	55	2.8
Tunisia	329	51	11.5	38	10.1	50	0.4

Source: Authors' calculations on 58 standardized company reports

In Tunisia, 26 companies from the food and beverage, mechanical, chemical, leather, and textile sectors participated in the demonstration phase of MED TEST II [4]. The companies range from SMEs with 20 full-time employees to large companies with 1,045 employees [1]. Out of all resource efficiency measures identified by the TEST team, 95% were incorporated into company action plans. With an investment of 14.1 million, these companies could save 9.7 million euros annually in production costs. The PBPs of 40% of the measures are less than or equal to 0.5 years, 31% are between 0.5 and 1.5 years, 17% are between 1.5 and 3 years and 12 % are greater than 3 years. The measures identified by the MED TEST team would result in significant resource savings and emission reductions described in Table 1.

4.2 *Energy Measures*

For the three countries, we use energy related data from company reports to calculatespecific investments, savings, and payback periods for all those resource efficiency measures that include energy efficiency improvements (Table 2).

For Algeria, the data from 12 company reports are as follows:

- Energy measures are 38% of the total resource efficiency measures;
- Energy investments are 14% of total investments;

For Morocco,the data from20 company reports are as follows:

- Energy measures are 43% of total resource efficiency measures;
- Energy investment are 69% of total investments;
- Energy savings are 55% of total savings;
- The average payback period for all energy related measures for all companies is 2.8 years.

For Tunisia,the data from26 company reportsare as follows:

- Energy measures are 51% of the total resource efficiency measures;
- Energy savings are 50 % of total savings;
- Energy investments are 38 % of total investments; and
- The average payback period for all energy measures for all companies is 1.0 years.

4.3: *Option Comparison*

In the case study of Tunisia, we compare the payback periods of energy, water, and material efficiency measures.

It is important to note that to compare the different payback periods, we had to decrease the number of data set to 18 companies for energy, 13 for materials

and 13 for water because of data limitations (Table 3).Most companies have short payback periods for energy, with 13 firms having a return on investment between 0.5 and 1.5 years. However, water and material measures are not negligible with severalmeasures having short paybackperiods that companies should implement before high payback period energy measures.

For these companies we find that:

- Water measures have an average payback period of 2.2 years.
- Materials measures have an average payback period of 1.6 years
- Energy measures have an average payback period of 1.0 years

innovative energy efficiency measures implemented in numerous developing countries.

The lack of energy efficiency measures with short-term payback periods (less than one year) in Morocco compared to Algeria and Tunisia needsadditional investigation. It is more than the difference in composition of manufacturing sectors that participated in MED TEST.

The number of energy efficiency measures identified in Tunisian companies came as a surprise because the Tunisian government has had an active energy efficiency program for more than 15 years.The program requires companies to undertake at government expense energy audits every five years and provides limited funding for the implementation of low-cost energy efficiencymeasures.

Table 3: Energy, water, material payback periods Tunisia

Tunisia	Average payback period	Number PBP options <0.5 yrs.	Number PBP options 0.5 to 1.5yrs	Number of PBP options 1.5 to 3 yrs	Number PBP options> 3.0 yrs.
water	2.2	3	5	2	3
material	1.6	6	5	1	2
energy	1.0	2	13	3	0

Source: Authors' calculations

5. DISCUSSION

Elements of the MFCA strengthen priority setting based on non-product output costs and establish an ad hoc information system for important raw material, water and energy flows and key processes. Its application suggests that in many cases it should proceed a narrowly focused energy assessment. Among other things, it could identify saving in water and raw material use, which in some cases also reduces energy use.

RECPAs undertaken since the 1990s are a potential source of technique and technology information that could improve resource efficiency. These assessments, including the many labelled Cleaner Production assessments, are often overlooked as sources of

6. CONCLUSIONS

We draw four conclusions from our detailed analysis of 58 TEST demonstration projects in three North African countries. First, the three inter-related methodologies (MFCA, RECPA and EMS/EnMS) make distinct but interrelated and essential contributions to the successful implementation of a TEST demonstration project. Stand-alone implementation of onlyMFCA or RECPA, although effective analytical tools, can easily lead to sub-optimal resource efficiency investments. Second, implementation of the TESTapproachsimultaneouslyidentifies several resource efficiency savings and pollution reductions in addition to those for energy, which constitute significant share, sometimes as high as 50% of the measures identified by

the TEST project. Third, for two out of three countries, a significant percentage of energy efficiency measures have averagepayback periods of less than one year. Fourth, in the case

of Tunisia, raw material and watermeasures have PBPscomparable to those for energy measures.

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