Technical and economic evaluations of water transport system

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Water transport cost is an essential part of the overall water production cost. Therefore, both technical and economic evaluations of the water transport are made in the new version of DEEP3 to estimate the water transport cost per m^3. Both models were integrated into the original structure of DEEP program through the water plant capacity, purchased electricity price, discount and interest rates in different template files. The main DEEP.XLs has been modified to allow the user to edit the input data and show results. Figure (1) and Figure (2) illustrate the user interface for both input data and output results.

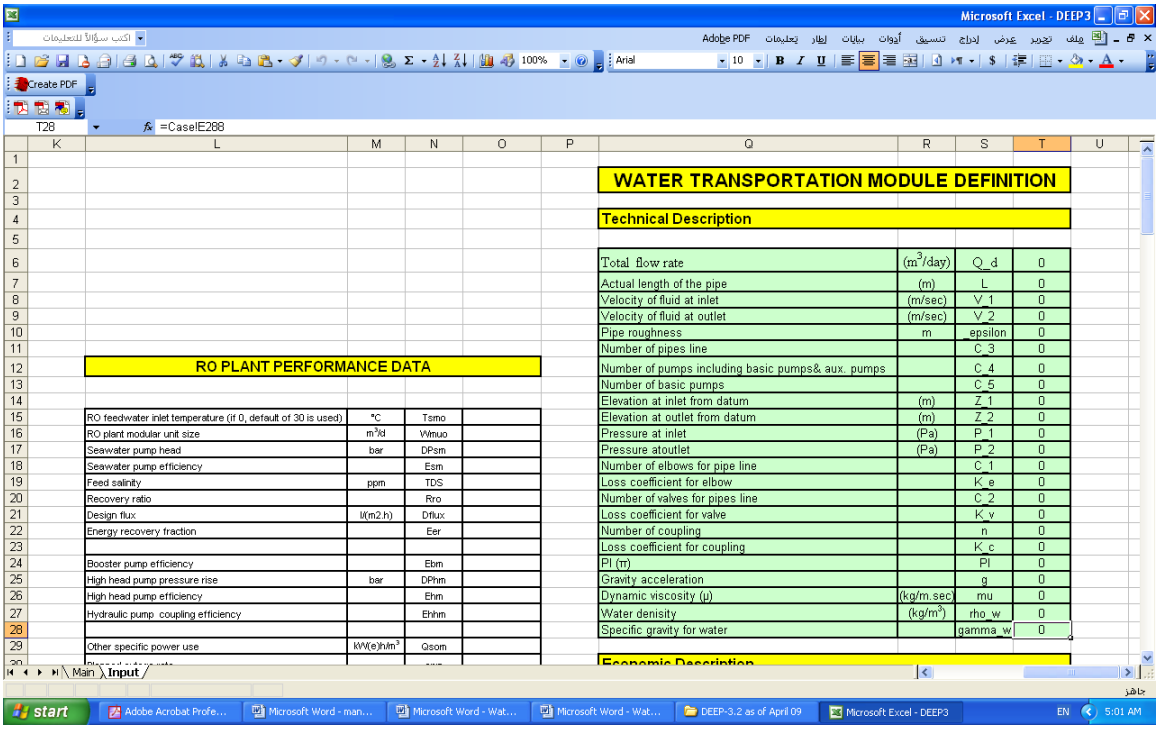

Figure (1): The modified user interface for water transport input data.

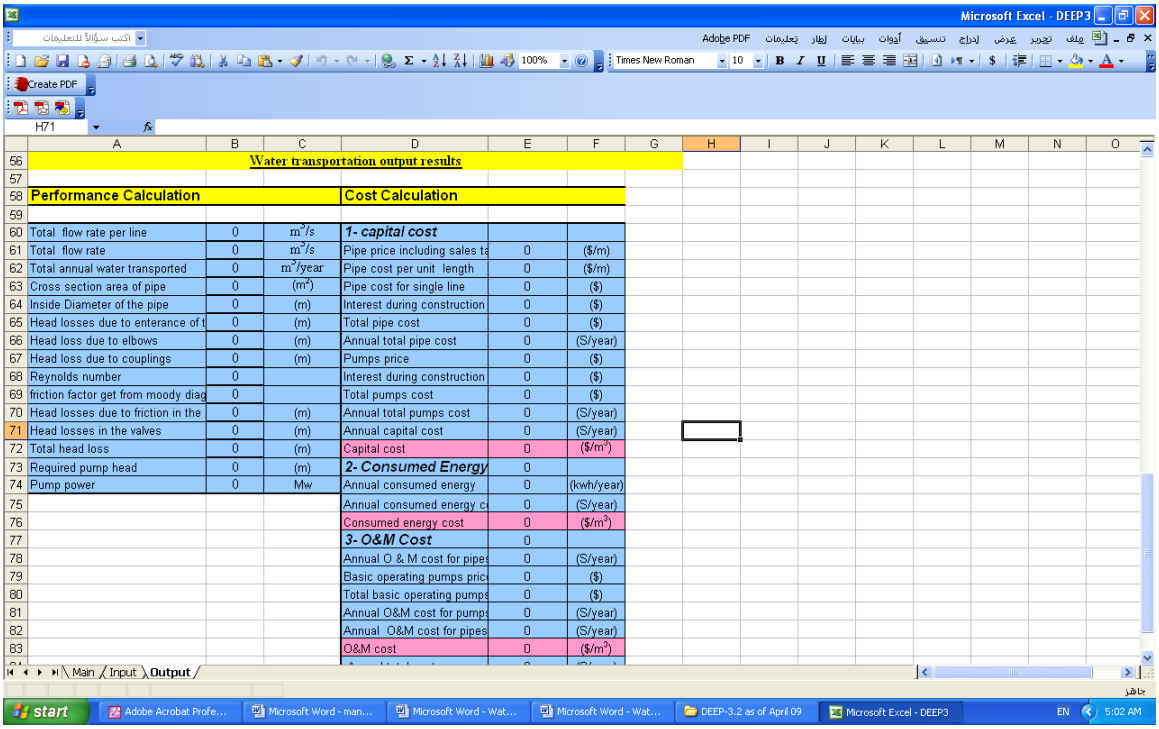

Figure (2): The modified user interface output results.

The package is capable to do both the technical and economical evaluation of the desalted water transport system that is used to transport the desalted water from the desalination plant to the consumer. The technical and economic water transport program was built as an integrated structure which includes simplified modules of the hydraulic and cost parameters. Table (1) shows the software spreadsheet for the water transport technical and economic required case input parameters while table (2) gives the final output results.

The main purpose of the technical calculation module is to calculate the total required pumping power by estimating the pressure loss during the

water transport systems. The pressure loss during the water transport systems is calculated as the sum of the pressure losses in the pump entrance, total piping length, and total number of couplings, valves and elbows.

Table (1): The software spreadsheet for the water transport technical and economic required case input parameters.

WATER TRANSPORTATION MODULE DEFINITION			
Technical Description			
Total flow rate	(m^3/day)	Q_d	100000
Actual length of the pipe	(m)	L	30000
Velocity of fluid at inlet	(m/sec)	V_1	1.5
Velocity of fluid at outlet	(m/sec)	V_2	1.5
Pipe roughness	m	epsilon	0
Number of pipes line		C_3	2
Number of pumps including basic pumps& aux. pumps		C_4	4
Number of basic pumps		C_5	2
Elevation at inlet from datum	(m)	Z_1	0
Elevation at outlet from datum	(m)	Z_2	0
Pressure at inlet	(Pa)	P_1	1
Pressure atoutlet	(Pa)	P_2	1
Number of elbows for pipe line		C_1	6
Loss coefficient for elbow		K_e	0.42
Number of valves for pipes line		C_2	6
Loss coefficient for valve		K_v	1
Number of coupling		n	5000
Loss coefficient for coupling		K_c	0.2
PI (π)		PI	3.14
Gravity acceleration		g	9.814
Dynamic viscosity (μ)	(kg/m.sec)	mu	0.00114
Water denisity	(kg/m^3)	rho_w	1000
Specific gravity for water		gamma_w	9797
Economic Description			
The interest rate	%	i_r	5
The discount rate rate	%	d_r	5
Construction lead time	months	Con_p	0
Pipeline operational availability factor	%	F_av	100
Energy price	($/Kw.h)	A_9	0.06
Pipe price per unit length	($/m)	A_1	308
Installation price for basic lines	($/m)	A_2	160
life time for pipes	(Year)	X_1	30
Specific pump price	($/Mwe)	Fp	110000
Pumps installation & building cost	($)	A_12	100000
life time for pumps	(Year)	X_2	15
sales tax factor		Fs	0.15

Annual O&M cost factor for pipes	(%/year)	Fo_1	0.03
Annual O&M cost factor for pumps	(%/year)	Fo_2	0.04

Table (2): The software spreadsheet for the water transport technical and economic final output results.

Performance Calculation			
Total flow rate per line	m^3/s	Q	0.578703704
Total flow rate	m^3/s	Qtot_1	1.157407407
Total annual water transported	$m^3/year$	Qtot_2	36500000
Cross section area of pipe	(m^2)	A_c	0.385802469
Inside Diameter of the pipe	(m)	d	0.701047868
Head losses due to enterance of the pipe	(m)	H_i	0.057316079
Head loss due to elbows	(m)	H_e	0.288873039
Head loss due to couplings	(m)	H_c	114.6321581
Reynolds number		R_e	922431.4056
friction factor get from moody diagram for smooth pipe		F	0.011745821
Head losses due to friction in the pipe	(m)	H_f	57.61869733
Head losses in the valves	(m)	H_v	0.687792949
Total head loss	(m)	H_loss	173.2848375
Required pump head	(m)	H_p	173.2848375
Pump power	W	P	0.982448816

Cost Calculation			
1- capital cost			
Pipe price including sales tax	($/m)	A_s	354.2
Pipe cost per unit length	($/m)	A_3	514.2
Pipe cost for single line	($)	A_4	15426000
Interest during construction for pipe line	($)	IDC_l	0
Total pipe cost	($)	A_5	30852000
Annual total pipe cost	($/year)	A_6	2006966.875
Pumps price	($)	A_11	432277.4789
Interest during construction for pumps	($)	IDC_p	0
Total pumps cost	($)	A_13	532277.4789
Annual total pumps cost	($/year)	A_14	51280.82996
Annual capital cost	($/year)	A_23	2058247.705
Capital cost	($/$m^3$)	A_24	0.056390348
2- Consumed Energy Cost			
Annual consumed energy	(kwh/year)	A_8	8606251.625
Annual consumed energy cost	($/year)	A_10	1032750.195
Consumed energy cost	($/$m^3$)	A_28	0.028294526
3- O&M Cost			
Annual O & M cost for pipes	($/year)	A_15	925560
Basic operating pumps price	($)	A_16	216138.7394
Total basic operating pumps cost	($)	A_17	316138.7394
Annual O&M cost for pumps	($/year)	A_18	12645.54958
Annual O&M cost for pipes & pumps	($/year)	A_19	938205.5496
O&M cost	($/$m^3$)	A_26	0.025704262

Annual total cost	($/year)	A_20	4029203.45
Water transport cost per m^3	($/$m^3$)	A_22	0.110389136
Water transport cost per m^3 and km	($/$m^3$/km)	A_29	0.003679638

The calculations of the economic models depend on an economic parameters such as the total pipe cost including installations and maintenance cost, energy price , total pumps cost including installation and building cost, life time for pipes and pumps, sales tax and the interest rate.

Figure (3) shows the flow chart of cost analysis of water transport cost. The economic evaluation is determined using two main parameters: capital cost and variable costs. The capital cost is the sum of pipe and pump cost (taxes, interest during construction and installation cost which include the pipe excavation and laying). The variable costs consist of electricity consumption and O&M for pipes and pumps. The present worth technique based on constant money terms is method to calculate and estimate the levelized discounted water transportation costs.

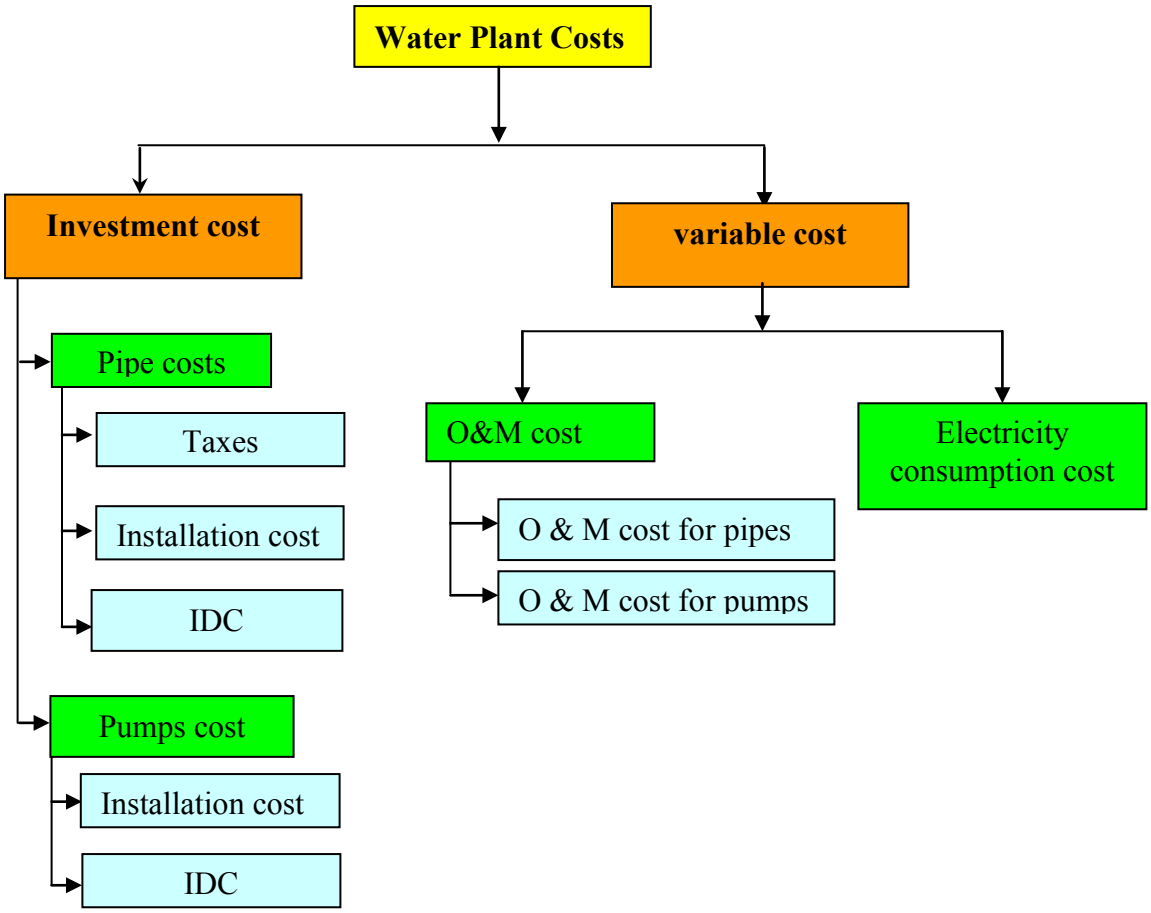

Figure (3): The flow chart of cost analysis of water transport cost