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Publication date:
1991

Document Version
Publisher's PDF, also known as Version of record

RISØ

Risø-M-2927(EN)

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A Wind Energy Planning System
User's Manual

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November 1991

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RISO-M--2927

DE92 506340

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Abstract.

The report describes the Wind Energy Planning system (WEP). It is intended as a decision support system to be used in the economic evaluation of wind energy projects. Such projects could be minor projects with only a single wind turbine or large wind farm projects consisting of several wind turbine plants.

In the WEP system, a wind turbine is described by data on initial investment, possible later reinvestments, O&M costs, expected yearly production, life time, and capacity factor. The raising of loans are modelled, too. Depending on which output report is created, the value of the wind generated electricity is calculated in two different ways: either the electricity is assumed to be sold at a price (time series) given by the user, or the alternative conventional power production is modelled by its specific investment, O&M costs, life time, effectivity, fuel mix, and time series for fuel prices. Using these data, capacity credit and saved fuel and O&M costs are calculated.

Due to the flexible data structure of the model, the user can easily create a scenario that models a large scale introduction of wind power. In such a scenario the gradual build up through several years of the wind power capacity can be modelled.

The report describes in detail the menu structure, the input facilities, the output reports, and the organization of data. Also included is an example with full input documentation and output reports.

ISBN-87-550-1727-4
ISSN 0418-6435

Grafisk Service, Risø 1991

CONTENTS

1. INTRODUCTION

This report describes the

Wind Energy Planning system (WEP).

It is intended as a decision support system to be used in the economic evaluation of wind energy projects. Such projects could be minor projects with only a single wind turbine or large wind farm projects consisting of several wind turbine plants.

In the WEP system, a wind turbine is described by data on initial investment, possible later reinvestments, O&M costs, expected yearly production, life time, and capacity factor. The raising of loans are modelled, too. Depending on which output report is created, the value of the wind generated electricity is calculted in two different ways: either the electricity is assumed to be sold at a price (time series) given by the user, or the alternative conventional power production is modelled by its specific investment, O&M costs, life time, effectivity, fuel mix, and time series for fuel prices (coal, fuel oil, diesel oil, and gas). Using these data, capacity credit and saved fuel and O&M costs are calculated.

Due to the flexible data structure of the model (see chapter 3), the user can easily - from data on single wind turbines or single wind power plants - create a scenario that models a large scale introduction of wind power. In such a scenario the gradual build up through several years of the wind power capacity can be modelled.

The system is based on menus (see chapter 4) in which the user by single key-strokes chooses between various facilities, e.g. the input facility for giving data (chapter 5), or the report facility for calculating output reports (chapter 6). Output reports can be displayed at the screen, sent to a printer, or

written to a DOS file. Also a full input documentation is available on printer or DOS file.

Although the WEP system is based on the Framework system by Ashton-Tate Corporation run under DOS on an IBM compatible PC, the user will never see Framework, the WEP system taking care of all communication with Framework.

The installation of the WEP system is described in chapter 2. The organization of data is dealt with in chapter 3.

2. INSTALLATION

The WEP system should be installed at an IBM compatible PC under the DOS operating system. Since Framework III by Ashton Tate Corporation is the basis for the WEP system, Framework III should be available.

The PC should have the following:

Processor	386, 386SX, or 486
RAM	640 kByte
Extended memory	3 MByte

To install the WEP system, create a new directory and copy all WEP files to this. To run the system, go to this directory and give the command "WEP".

Following is a list of all WEP-files with a short description of the content.

File		Frame	Content
WEP	BAT		BAT file to start WEP.
FRONT_PA	FW3	Front page	Front page.
WIND_ENE	FE3	Wind energy planning	All menus.
DBMANAGE	FW3	DBmanager	A general database manager.
INPUT_MA	FW3	Input manager	Interface between the user and the general database manager.
UPDATE	FW3	Update	Handles updating of dataset.
PTOT	FW3	Ptot	Prints all data referenced by a scenario, i.e. a "total scenario".

File	Frame	Content
ROUTINES FW3	Routines	A collection of general routines.
KEY_DEF FW3	Key Def	Key definitions.
GLOBALS FW3	Globals	Global data (database names and default data-set names).
DBINDEX FW3	DBindex	Template for displaying a database index.
WEP_S_DB FW3	WEP_S_DB)	Databases for scenarios,
WEP_E_DB FW3	WEP_E_DB)	economic data,
WEP_A_DB FW3	WEP_A_DB)-	avoided costs data,
WEP_W_DB FW3	WEP_W_DB)	wind turbine data,
WEP_L_DB FW3	WEP_L_DB)	and loan data.
WEP_S_GP FW3	WEP_S_GP)	Routines to get data
WEP_E_GP FW3	WEP_E_GP)	from database to input
WEP_A_GP FW3	WEP_A_GP)-	template, and to put
WEP_W_GP FW3	WEP_W_GP)	data back into the data-
WEP_L_GP FW3	WEP_L_GP)	base. Handles, scen- arios, economic data, avoided costs data, wind turbine data, and loan data.
WEP_S_IN FW3	WEP_S_IN)	Input template and input
WEP_E_IN FW3	WEP_E_IN)	documentation template
WEP_A_IN FW3	WEP_A_IN)-	for scenarios, economic
WEP_W_IN FW3	WEP_W_IN)	data, avoided costs
WEP_L_IN FW3	WEP_L_IN)	data, wind turbine data, and loan data.
PREP_REP FW3	Prep Report	Prepares the calculation and printing of reports.
CALC_CAS FW3	Calc Cash flow	Calculates cash flow analysis report.
CALC_ECO FW3	Calc Economic	Calculates Economic analysis report.
CALC_FIN FW3	Calc Financial	Calculates Financial analysis report.
REPORTS FW3	Reports	Report templates.

3. ORGANIZATION OF DATA

To set up a full input for a calculation, the user should give the following date

- scenario data
- economic data
- avoided costs data
- wind turbine data
- loan data.

In chapter 5 these data will be dealt with in detail. Here, only a general discription will be given.

The data are organized in five databases according to the above list. Each database holds several datasets, identified by individual names. To start a calculation, after all input has been given to the WEP system - and stored in the databases - the user gives the name of a scenario which then in itself contains the names of those datasets from the other four databases, that should be used in the calculation.

Scenario data first of all consists of the names of the economic data and avoided costs data. Moreover, scenario data contains a list of windturbines. For each wind turbine, this list gives the name, the number of turbines, the year of production start, and finally the name of the loan used to finance this particular turbine.

Economic data gives the inflation, discount rate, heat content of fuels, fuel prices, and price of electricity.

Avoided costs data give information on the conventional power production, transmission, and distribution, that is avoided due to the wind power (capacity credit and fuel savings).

Wind turbine data describe a single wind turbine or a whole wind power plant by giving the installed capacity, the yearly production, the life time, possible reinvestments, and O&M costs. The concept of wind turbine data can also be used to model some activity (e.g. to buy the land needed for a wind power plant, or to construct the roads) that calls for some investments and/or maintenance costs. To model such activities, the user just need to specify a power production of zero.

Loan data simply gives the interest rate and term (number of years to pay back the loan).

4. MENUS

The WEP system is controlled by means of a hierarchy of menus as shown in the overview below. Each line corresponds to a menu in which the user can choose among several options shown at the next indentation level and thus (except for the bottom level) get a new menu at a lower level.

The user chooses an option by either pressing the key corresponding to the first letter in the option, or by pressing the arrow-keys until the option is high-lighted and then pressing the return-key. The user returns to the menu above the one displayed by pressing the OUT-key (or "-"-key on the numeric keypad). To exit from the top menu and leave the WEP system, press the "E"-key.

The bottom line of the screen is used for help information: When the menu displayed is not a bottom level menu, the bottom line shows the options in the menu which would be displayed if the high-lighted option were chosen. When the menu displayed is a bottom level menu, the bottom line shows a text telling what would happen if the high-lighted option were chosen.

When menus are displayed, the action of the keyboard is controlled by the WEP system. The following keys can be used:

Key	Action
Down arrow)	
Up arrow)	
Right arrow)	Move the highlighting to the next/previous/
Left arrow)	next/previous/top/bottom menu option.
Home)	
End)	
Return	Choose the menu option highlighted.
In [1]	Choose the menu option highlighted.
Out [2][3]	Return to the calling menu
ESC [3]	Return to the calling menu.
Letter[4]	Choose the menu option starting with the given letter.

1) The "In"-key is "F12" or "+" on the numeric keypad.
2) The "Out"-key is "F11" or "-" on the numeric keypad.
3) Should not be used in the main (top level) menu. Use "E" instead.
4) Only letters that are the first letter in a menu option. To return from any menu, except the main (top level) menu, press the "Out"-key or the "ESC"-key. To exit from the main menu (i.e. to exit WEP), press the letter "E".

Overview of menus:

Wind energy planning
1 Manage input
  1.1 Wind turbine data
    1.1.1 Make
    1.1.2 Update
    1.1.3 New name
    1.1.4 Copy
    1.1.5 Delete
    1.1.6 Work on two databases
    1.1.7 Return : Press {Out}
  1.2 Economic data
    1.2.1 Make
    1.2.2 Update
    1.2.3 New name
    1.2.4 Copy
    1.2.5 Delete
    1.2.6 Work on two databases
    1.2.7 Return : Press {Out}
  1.3 Avoided costs data
    1.3.1 Make
    1.3.2 Update
    1.3.3 New name
    1.3.4 Copy
    1.3.5 Delete
    1.3.6 Work on two databases
    1.3.7 Return : Press {Out}
  1.4 Loan data
    1.4.1 Make
    1.4.2 Update
    1.4.3 New name
    1.4.4 Copy
    1.4.5 Delete
    1.4.6 Work on two databases
    1.4.7 Return : Press {Out}
  1.5 Scenario data
    1.5.1 Make
    1.5.2 Update
    1.5.3 New name
    1.5.4 Copy
    1.5.5 Delete
    1.5.6 Work on two databases
    1.5.7 Return : Press {Out}
  1.6 Return : Press {Out}
2 Input documentation
  2.1 Printer
    2.1.1 Wind turbine data
    2.1.2 Economic data
    2.1.3 Avoided costs data
    2.1.4 Loan data
    2.1.5 Scenario data
    2.1.6 Total Scenario data
    2.1.7 Return : Press {Out}
  2.2 DOS file
    2.2.1 Wind turbine data

```
        2.2.2  Economic data
        2.2.3  Avoided costs data
        2.2.4  Loan data
        2.2.5  Scenario data
        2.2.6  Total Scenario data
        2.2.7  Return : Press {Out}
   2.3  Return : Press {Out}
3  Reports
   3.1  Screen
        3.1.1  Financial analysis
        3.1.2  Cash flow analysis
        3.1.3  Economic analysis
        3.1.4  Return : Press {Out}
   3.2  Printer
        3.2.1  Financial analysis
        3.2.2  Cash flow analysis
        3.2.3  Economic analysis
        3.2.4  All reports
        3.2.5  Return : Press {Out}
   3.3  DOS file
        3.3.1  Financial analysis
        3.2.2  Cash flow analysis
        3.3.3  Economic analysis
        3.3.4  All reports
   3.4  Return : Press {Out}
4  Exit from system
```

In the following pages all menus are discussed one at the time.

Main menu: Wind energy planning

```
Wind energy planning

     Manage input
     Input documentation
     Reports
     Exit from system
```

To get this menu, execute the file WEP.BAT from DOS by giving the command WEP.

Description of options:

1: Manage input
   By choosing this option the user gets access to all input facilities of the system.
2: Input documentation
   Choose this option to get a documentation of input, either on printer or on a DOS file. As mentioned in chapter 5, the user is also able to get an input documentation on printer when updating a dataset.
3: Reports
   Choose this option to create an output report, either to be displayed at the screen, to be sent to the printer, or to be written to a DOS file. As mentioned in chapter 6, a report displayed at the screen can easily be printed.
4: Exit from system
   This option is chosen by pressing the "E"-key.

Menu 1: Manage input

Manage input

Wind turbine data
Economic data
Avoided costs data
Loan data
Scenario data
Return : Press {Out}

To get this menu, choose the "Manage input" option in the main menu.

Discription of options:

1.1: Wind turbine data
Choose this option to get access to wind turbine data.
1.2: Economic data
Choose this option to get access to economic data.
1.3: Avoided costs data
Choose this option to get access to avoided costs data.
1.4: Loan data
Choose this option to get access to loan data.
1.5: Scenario data
Choose this option to get access to scenario data.
1.6: Return
Press the {Out}-key to return to the main menu.

Menu 1.X: <Data type>

<Data type>

Make
Update
New name
Copy
Delete
Work on two databases
Return : Press {Out}

1.X: <Data type> could be 1.1: Wind turbine data
1.2: Economic data
1.3: Avoided costs data
1.4: Loan data
1.5: Scenario data

To get this menu, choose the <Data type> option in the "Manage input" menu.

Description of options:

1.X.1: Make
Choose this option to make a new dataset.

1.X.2: Update
Choose this option to update an existing dataset.

1.X.3: New name
Choose this option to give an existing dataset a new name.

1.X.4: Copy
Choose this option to copy an existing dataset.

1.X.5: Delete
Choose this option to delete an existing dataset.

1.X.6: Work on two databases
Choose this option to copy a dataset from one database

to another.

1.X.7: Return

Press the {Out}-key to return to the "Manage input" menu.

Options 1.X.1 to 1.X.6:

The user is prompted for the dataset name(s) and database names (option 1.X.6). The WEP system supplies the user with default names of datasets (except for option 1.X.1) and databases. A default name is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the dataset name "H" or "Help" (the system is not case-sensitive), a list of existing names is displayed.

Menu 2 : Input documentation

```
Input documentation

      Printer
      DOS file
      Return : Press {Out}
```

To get this menu, choose the "Input documentation" option in the main menu.

Description of options:

2.1 : Printer
Choose this option to send the input documentation to the printer.

2.2 : DOS file
Choose this option to write the input documentation to a DOS file. The DOS file name equals the first 8 characters in the dataset name with blank replaced by underscore. The file name extension is PRT.

2.3 : Return
Press the {Out}-key to return to the main menu.

Menu 2.1: Printer

Printer

Wind turbine data
Economic data
Avoided costs data
Loan data
Scenario data
Total Scenario data
Return : Press {Out}

To get this menu, choose the "Printer" option in the "Input documentation" menu.

Description of options:

2.1.1: Wind turbine data
Choose this option to get a printed documentation of a wind turbine dataset.

2.1.2: Economic data
Choose this option to get a printed documentation of an economic dataset.

2.1.3: Avoided costs data
Choose this option to get a printed documentation of an avoided costs dataset.

2.1.4: Loan data
Choose this option to get a printed documentation of a loan dataset.

2.1.5: Scenario data
Choose this option to get a printed documentation of a scenario dataset.

2.1.6: Total Scenario data
Choose this option to get a printed documentation of a scenario dataset together with all datasets of any type referenced by this scenario.

2.1.7: Return

Press the {Out}-key to return to the "Input documentation" menu.

Options 2.1.1 to 2.1.6:

The user is prompted for the name of the dataset. The WEP system supplies the user with a default name, which is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the name "H" or "Help" (the system is not case-sensitive), a list of existing names is displayed.

Menu 2.2: DOS file

DOS file

Wind turbine data
Economic data
Avoided costs data
Loan data
Scenario data
Total Scenario data
Return : Press {Out}

To get this menu, choose the "DOS file" option in the "Input documentation" menu.

Description of options:

2.2.1: Wind turbine data
Choose this option to write a documentation of a wind turbine dataset to a DOS file.

2.2.2: Economic data
Choose this option to write a documentation of an economic dataset to a DOS file.

2.2.3: Avoided costs data
Choose this option to write a documentation of an avoided costs dataset to a DOS file.

2.2.4: Loan data
Choose this option to write a documentation of a loan dataset to a DOS file.

2.2.5: Scenario data
Choose this option to write a documentation of a scenario dataset to a DOS file.

2.2.6: Total Scenario data
Choose this option to get a documentation of a scenario dataset together with all datasets of any type referenced by this scenario. The documentation is written to

a DOS file.

2.2.7: Return

Press the {Out}-key to return to the "Input documentation" menu.

Options to 2.2.1 to 2.2.6:

The user is prompted for the name of the dataset. The WEP system supplies the user with a default name, which is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the name "H" or "Help" (the system is not case-sensitive), a list of existing names is displayed.

Menu 3: Reports

Reports

Screen
Printer
DOS file
Return : Press {Out}

To get to this menu, choose the "Reports" option in the main menu.

Description of options:

3.1: Screen
Choose this option to display the report on the screen.

3.2: Printer
Choose this option to send the report to the printer.

3.3: DOS file
Choose this option to write the report to a DOS file. The DOS file name equals the first 6 characters in the scenario name preceeded by "F_", "C_", or "E_" for the Financial, Cash flow, and Economic analysis reports. Blanks are replaced by underscore. The file name extension is PRT.

3.4: Return
Press the {Out}-key to return to the main menu.

Menu 3.1: Screen

Screen

Financial analysis
Cash flow analysis
Economic analysis
Return : Press {Out}

To get this menu, choose the "Screen" option in the "Reports" menu.

Descriptions of options:

3.1.1: Financial analysis
Choose this option to have the Financial analysis report displayed at the screen.

3.1.2: Cash flow analysis
Choose this option to have the Cash flow analysis report displayed at the screen.

3.1.3: Economic analysis
Choose this option to have the Economic analysis report displayed at the screen.

3.1.4: Return
Press the {Out}-key to return to the "Reports" menu.

Options 3.1.1 to 3.1.3:

The user is prompted for a scenario name. The WEP system supplies the user with a default name, which is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the scenario name "H" or "Help" (the system is not case-sensitive), a list of existing scenario names is displayed.

Menu 3.2: Printer

Printer

Financial analysis
Cash flow analysis
Economic analysis
All reports
Return : Press {Out}

To get this menu, choose the "Printer" option in the "Reports" menu.

Description of options:

3.2.1: Financial analysis
Choose this option to send the Financial analysis report to the printer.

3.2.2: Cash flow analysis
Choose this option to send the Cash flow analysis report to the printer.

3.2.3: Economic analysis
Choose this option to send the Economic analysis report to the printer.

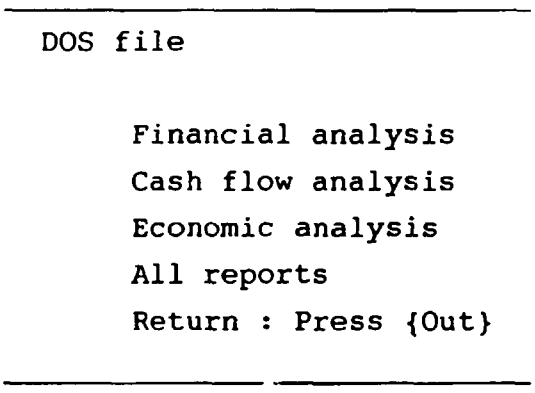
3.2.4: All reports
Choose this option to send all reports to the printer.

3.2.5: Return
Press the {Out}-key to return to the "Reports" menu.

Options 3.2.1 to 3.2.4:

The user is prompted for a scenario name. The WEP system supplies the user with a default name, which is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the scenario name "H" or "Help" (the system is not case-sensitive), a list of existing scenario names is displayed.

Menu 3: DOS file



To get this menu, choose the DOS file option in the "Reports" menu.

Description of options:

3.3.1: Financial analysis
Choose this option to write the Financial analysis report to a DOS file.

3.3.2: Cash flow analysis
Choose this option to write the Cash flow analysis report to a DOS file.

3.3.3: Economic analysis
Choose this option to write the Economic analysis report to a DOS file.

3.3.4: All reports
Choose this option to write all reports to DOS files.

3.3.5: Return
Press the {Out}-key to return to the "Reports" menu.

Options 3.3.1 to 3.3.4:

The user is prompted for a scenario name. The WEP system supplies the user with a default name, which is accepted by pressing the {Return}-key. Moreover, the system supplies a help facility: If the user gives the scenario name "H" or "Help" (the system is not case-sensitive), a list of existing scenario names is displayed.

5. INPUT FORMS

In this chapter the input forms for the five types of data are considered. The definition of all data items is given. How the input data are used to calculate the reports, is discussed in chapter 6.

The five input forms snown in this chapter are used for two purposes: Firstly, they are used when the user is updating a dataset. The appropriate form is displayed at the screen with the dataset in question filled in. The user is then free to accept the value of all data items or to move the cursor to any data item and change it.

Secondly, the five input forms are used when making an input documentation. In this case the form is supplemented with time and date of printing.

When a dataset is being updated, the action of the keyboard is *controlled by the WEP system. The following keys can be used:*

Key	Action
Letter [1] Figure [2] .(period)	To change a data item.
Down arrow Up arrow Left arrow Right arrow	Move one position down/up/left/right.
Page up Page down	Move one page up/down.
Home End	Move to start/end of line.
Tab Shift-Tab Return Backspace	Move one position right/left/down/left.
Ctrl-Home	Move to upper left corner of input form.
Ctrl-End	Move to lower right corner of input form.
Del	Delete data item.
F10	Print the dataset.
Out[3]	Write the updating of the dataset to the database, and return to the menu.
Esc	Cancel updating, and return to the menu.
F2[4]	Edit formula.
F4[4]	Size.
F6[4]	Extend select.
F7[4]	Move.
F8[4]	Copy
F9[4]	Zoom.
Shift-F7[4]	Cut.
Shift-F8[4]	Paste.

1) A to Z and a to z.
2) 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.
3) The "Out"-key is "F11" or "-" on the numeric keypad.
4) See the Framework manual for a full explanation. You can easily do without using these keys.

5.1. Wind turbine data

Below is shown the input form for wind turbine data. The data filled in are the default data that are assigned to a new dataset when it is made.

12:57:21. Feb 28, 1991.

Wind turbine data

Name	:	Wdefault	
	:		
Installed capacity	:	0	kW
Yearly production	:	0	MWh
Life time	:	0	years
Base year for costs	:	0	year
Investment	:	0	kf
- own production	:	0	%

	Reinvestments		O&M
	Amount	Own produc.	per year
Year	kf	%	%
1	0	0	.00
2	0	0	.00
3	0	0	.00
4	0	0	.00
5	0	0	.00
6	0	0	.00
7	0	0	.00
8	0	0	.00
9	0	0	.00
10	0	0	.00
11	0	0	.00
12	0	0	.00
13	0	0	.00
14	0	0	.00
15	0	0	.00
16	0	0	.00
17	0	0	.00
18	0	0	.00
19	0	0	.00
20	0	0	.00
21	0	0	.00
22	0	0	.00
23	0	0	.00
24	0	0	.00
25	0	0	.00
26	0	0	.00
27	0	0	.00
28	0	0	.00
29	0	0	.00
30	0	0	.00

Year = 1 : Year for initial investment.
O&M : % of initial investment.

The data items are as follows:

Name:	The name of the dataset.
Installed capacity:	The capacity of the wind turbine.
Yearly production:	The yearly wind power production.
Life time:	The number of years for which the wind turbine will be operated. It is assumed that the terminal value at the end of this period is zero.
Base year for costs:	Investments and reinvestments for this dataset are given in the base year's money.
Investment:	The initial investment. It is assumed that it is paid in the first year of production.
Reinvestment:	For each year a reinvestment can be given.
Own production:	For initial investment and reinvestments the own production (i.e. not import) is specified. In the present version of the WEP system, this data item is not used in any output report.
O&M:	Yearly operation and maintenance costs. Should be given as a percentage of initial investment.

Reinvestments and O&M are given as time series in relative years (i.e. 1, 2, 3, etc.) and not calender years (i.e. 1990, 1991, 1992, etc.). First year of production is year 1. In scenario data, wind turbine data are fixed in calender years.

A wind turbine dataset can model a single wind turbine or a whole wind power plant. Moreover, it can be used to model some activity (e.g. land acquisition, road construction), that calls for investments and possibly O&M costs, but does not in itself give rise to any electricity production. For such an activity the yearly production should of course be given the value zero.

5.2. Economic data

Below is shown the input form for economic data. The data filled in are the default data that are assigned to a new dataset when it is made.

12:58:30. Feb 28, 1991.

Economic data

Name	:	Edefault	
	:		
Base year for prices	:	0	year
Inflation	:	.00	%
Discount rate	:	.00	%
	:		
	:		
Heat content :	:		
- Coal	:	.00	GJ/t
- Fuel oil	:	.00	GJ/m3
- Diesel oil	:	.00	GJ/m3
- Gas	:	.00	GJ/1000m3

Fuel and electricity prices :

Year	Coal £/t	Fuel oil £/m3	Diesel oil £/m3	Gas £/1000m3	Electricity £/kWh
1990	.00	.00	.00	.00	.000
1991	.00	.00	.00	.00	.000
1992	.00	.00	.00	.00	.000
1993	.00	.00	.00	.00	.000
1994	.00	.00	.00	.00	.000
1995	.00	.00	.00	.00	.000
1996	.00	.00	.00	.00	.000
1997	.00	.00	.00	.00	.000
1998	.00	.00	.00	.00	.000
1999	.00	.00	.00	.00	.000
2000	.00	.00	.00	.00	.000
2001	.00	.00	.00	.00	.000
2002	.00	.00	.00	.00	.000
2003	.00	.00	.00	.00	.000
2004	.00	.00	.00	.00	.000
2005	.00	.00	.00	.00	.000
2006	.00	.00	.00	.00	.000
2007	.00	.00	.00	.00	.000
2008	.00	.00	.00	.00	.000
2009	.00	.00	.00	.00	.000
2010	.00	.00	.00	.00	.000
2011	.00	.00	.00	.00	.000
2012	.00	.00	.00	.00	.000
2013	.00	.00	.00	.00	.000
2014	.00	.00	.00	.00	.000
2015	.00	.00	.00	.00	.000
2016	.00	.00	.00	.00	.000
2017	.00	.00	.00	.00	.000
2018	.00	.00	.00	.00	.000
2019	.00	.00	.00	.00	.000

The data items are as follows:

Name: The name of the dataset.

Base year for prices: Fuel[1] prices and price of electricity[2] are for this dataset given in the base year's money.

Inflation: The yearly inflation rate.

Discount rate: The yearly discount rate. Is used to find net present values, and to transform costs from for instance fixed £(1995) to fixed £(1990).

Heat content: Heat content of fuels[1] (coal, fuel oil, diesel oil, and gas).

Fuel prices: Time series for coal, fuel oil, diesel oil, and gas prices[1].

Electricity price: Time series for electricity price[2].

1) Data on these fuels are together with the avoided costs data used when calculating the capacity value and value of production for the economic analysis report.
2) This price of electricity is used when calculating the income from selling the wind generated electricity. This income is used in the cash flow and financial analyses reports.

5.3. Avoided costs data

Below is shown the input form for avoided costs data. The data filled in are the default data that are assigned to a new dataset when it is made.

Avoided costs data are representing the alternative power production that would have taken place, if the wind power project in question did not exist. These data are, together with fuel data (part of economic data) and data on transmission losses and capacity factors (part of scenario data), used to calculate the capacity value and value of production for the economic analysis report. Also the possible savings in expansion of transmission and distribution systems due to the wind project is modelled.

It should be noticed that avoided costs data are not used in the financial analysis and cash flow analysis reports. Instead, the price of electricity given as part of economic data is used.

12:59:36. Feb 28, 1991.

Avoided costs data

Name	:	Adefault	
Base year for prices	:	0	year
Power plant :	:		
- Investment	:	0	£/kW
- Life time	:	0	years
- O&M per year	:	0	% of investment
- Effectivity	:	0	%
- Fuel mix :	:		
- - Coal	:	0	%
- - Fuel oil	:	0	%
- - Diesel oil	:	0	%
- - Gas	:	0	%
Transmission :	:		
- Investment	:	0	£/kW
- Life time	:	0	years
Distribution :	:		
- Investment	:	0	£/kW
- Life time	:	0	years

The data items are as follows:

Name:	Name of the dataset.
Base year for prices:	Investments (power plant, transmission and distribution) for this dataset are given in the base year's money.
Power plant:	The alternative conventional thermal power plant system.
- Investment:	Investment costs.
- Life time:	The life time. It is assumed that the terminal value at the end of this period is zero.
- O&M:	Yearly operation and maintenance costs. Should be given as a percentage of investment.
- Effectivity:	The effectivity in converting the fuel energy into electricity.
- Fuel mix:	The fuel mix. The sum of the coal, fuel oil, diesel oil, and gas figures should be 100%.
Transmission:	The power transmission system.
- Investment:	Transmission system investment.
- Life time:	Life time of the transmission system. It is assumed that the terminal value at the end of this period is zero.
Distribution:	The power distribution system.
- Investment:	Distribution system investment.
- Life time:	Life time of the distribution system. It is assumed that the terminal value at the end of this period is zero.

5.4. Loan data

Below is shown the input form for loan data. The data filled in are the default data that are assigned to a new dataset when it is made.

13:00:15. Feb 28, 1991.

Loan data

Name	:	Ldefault
	:	
Interest rate	:	0 % per year
Term	:	0 years

The data items are as follows:

Name: Name of the dataset.

Interest rate: Yearly interest rate.

Term: The number of years during which the loan should be paid back.

Loans are assumed to be annuity loans with a yearly payment of $r/(1-(1+r)^{-1})$, where r is the interest rate and n is the pay-back period.

Loans are used in the cash flow analysis report in connection with wind turbine investments and reinvestments. The full pay-back period is used for initial investments. However, for later reinvestments the pay-back time might be reduced so that all loans due to reinvestments are paid back within the life time of the wind turbine in question.

Links between wind turbines and loans are defined in the scenario data.

5.5. Scenario data

Below is shown the input data for scenario data. The data filled in are the default data that are assigned to a new dataset when it is made.

Since a scenario dataset is referencing an economic dataset, an avoided costs dataset, and one or several wind turbine datasets and loan datasets, it could be looked upon as a containing dataset. By giving only a scenario name, a total calculation of all reports can be started.

13:00:52. Feb 28, 1991.

Scenario data

Name	: Sdefault	
	:	
Economic data	:	
Avoided costs data	:	
	:	
Base year for reports	: 0	
	:	
Loss in transmission	:	
to consumers from :	:	
- conv. power plant	: 0	%
- wind power plant	: 0	%
	:	
Capacity factor of wind	:	
power plant regarding :	:	
- production	: 0	%
- transmission	: 0	%
- distribution	: 0	%

Wind power project :

Wind turbine	Number of units	Year of production start	Loan data
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	

The data items are as follows:

Name:	Name of the scenario dataset.
Economic data:	Name of the economic dataset to be used.
Avoided costs data[1]:	Name of the avoided costs dataset to be used.
Base year for reports:	In the financial analysis and economic analysis reports and in the last column of the cash flow analysis report all figures representing costs or income are given in the base year's money.
Loss in transmission to consumers from:	Percentage loss when transmitting power to the load center.
- conv. power plant:	- when power is generated at the alternative conventional thermal power plant.
- wind power plant:	- when power is generated at the wind power plant.
Capacity factor of wind power plant:	Capacity factor[2] (capacity credit) (percentage)
- production:	- avoided expansion of conventional thermal power plant
- transmission:	- avoided expansion of transmission system.
- distribution:	- avoided expansion of distribution system.
Wind turbine[3]:	Names of wind turbine datasets to be included in the calculations.
Number of units:	For each wind turbine name, the number of this wind turbine to be in-

cluded.

Year of production start: For each wind turbine name, the first year of production (which is equivalent to the year of initial investment).

Loan data[4]: For each wind turbine name, the name of the loan dataset to be used in the cash flow analysis report.

1) Necessary only if the economic analysis report is to be calculated.

2) If no capacity credit is expected, a zero should be given. If the wind project is expected to call for an increased investment in transmission or distribution systems (compared to a conventional expansion of the production system), a negative figure should be given.

3) The same wind turbine dataset might be referenced in several lines with different year of production start and/or loan data.

4) Necessary only if the cash flow analysis report is to be calculated.

6. REPORTS

In its present version, the WEP system is able to produce three output reports (financial, cash flow, and economic analysis reports). These reports can be displayed at the screen, sent to a printer, or written to DOS files.

It should be noticed that taxes are not accounted for in any report. If the rules for taxation could be modelled on a project basis (i.e. without incorporating the total economy of the company), new reports could easily be defined and included in the system. Likewise, the existing reports could easily be changed to fit any user's need.

The main differences between the three reports are:

1) Financial analysis report.
   The wind generated electricity is sold at a price (time series) given by the user as part of economic data.
   No loans are modelled.

2) Cash flow analysis report.
   The wind generated electricity is sold at a price (time series) given by the user as part of economic data.
   Funds for investments and reinvestments are raised by loans. The amortization of these loans are part of the report.

3) Economic analysis report.
   The value of the wind generated electricity is calculated by estimating the avoided costs in the conventional thermal power system. Reduction in fuel and O&M costs are found together with the capacity credit (regarding power plant, transmission, and distribution system).
   No loans are modelled.

Below the action of the keyboard, when reports are displayed at the screen, will be described. Next, each of the output reports will be dealt with.

When a report is displayed at the screen, the action of the keyboard is controlled by the WEP system. The following keys can be used:

Key	Action
Down arrow Up arrow Right arrow Left arrow	Move one position down/up/right/left.
Home End	Move to start/end of line.
Page up Page down	Move one page up/down.
Tab Shift-Tab	Move one position to the right/left.
Return	Move one position down.
Ctrl-Home	Move to upper left corner.
Ctrl-End	Move to lower right corner.
Out[1] ESC	Return to the menu.
F10	Print the report.
F4[2]	Size.
F9[2]	Zoom.

1) The "Out"-key is "F11" or "-" on the numeric keypad.

2) See the Framework manual for a full explanation. You can easily do without using these keys.

6.1. Financial analysis report

Below an example of a financial analysis report is shown.

1:21:25. Mar 6, 1991.

Scenario : SCEN Financial analysis Fixed 1991-prices.

Year	Installed capacity MW	Installed cap. acc. MW	Production MWh	Investment M£	O&M M£	Income M£	Net income M£
1990	.00	.00	.00	.000	.000	.000	.000
1991	.00	.00	.00	.000	.000	.000	.000
1992	1.50	1.50	3000.00	3.858	.231	.648	-3.442
1993	.00	1.50	3000.00	.000	.193	.648	.455
1994	.00	1.50	3000.00	.000	.154	.648	.494
1995	.00	1.50	3000.00	.000	.154	.648	.494
1996	.00	1.50	3000.00	.000	.154	.648	.494
1997	.00	1.50	3000.00	.000	.154	.648	.494
1998	.00	1.50	3000.00	.000	.154	.648	.494
1999	.00	1.50	3000.00	.000	.193	.648	.455
2000	.00	1.50	3000.00	.000	.231	.648	.417
2001	.00	1.50	3000.00	1.286	.193	.648	-.831
2002	.00	1.50	3000.00	.000	.154	.648	.494
2003	.00	1.50	3000.00	.000	.154	.648	.494
2004	.00	1.50	3000.00	.000	.154	.648	.494
2005	.00	1.50	3000.00	.000	.154	.648	.494
2006	.00	1.50	3000.00	.000	.154	.648	.494
2007	.00	1.50	3000.00	.000	.154	.648	.494
2008	.00	1.50	3000.00	.000	.154	.648	.494
2009	.00	1.50	3000.00	.000	.193	.648	.455
2010	.00	1.50	3000.00	.000	.231	.648	.417
2011	.00	1.50	3000.00	.000	.270	.648	.378
2012	.00	1.50	3000.00	.000	.309	.648	.339
2013	-1.50	.00	.00	.000	.000	.000	.000
2014	.00	.00	.00	.000	.000	.000	.000
2015	.00	.00	.00	.000	.000	.000	.000
2016	.00	.00	.00	.000	.000	.000	.000
2017	.00	.00	.00	.000	.000	.000	.000
2018	.00	.00	.00	.000	.000	.000	.000
2019	.00	.00	.00	.000	.000	.000	.000
NPV				4.003	1.560	5.604	.038
SUM			63000.00				

10.20 % : Internal rate of return for Net income

.21 £/kWh : Discounted levellized production cost

10.00 % : Discount rate

The content of the financial analysis report is as follows:

1) Time and date of printing.

2) The name of the scenario.

3) The name of the report (Financial analysis).

4) The base year of money.

5) Year.

6) Installed capacity.
All wind turbines reference in the scenario are included taking into account the number of units indicated by the scenario. The capacity of a wind turbine is added in its first year of production and subtracted in the year following its last year of production.

7) Installed capacity accumulated.
This column, which is found by accumulating 6) above, gives for any year the total installed wind power capacity.

8) Production.
The total production for all wind turbines.

9) Investment.
The investments and reinvestments for all wind turbines.

10) O&M.
Operation and maintenance costs for all wind turbines.

11) Income.
The income from selling the wind generated electricity. The income is calculated from 8) above and the price of electricity which is part of economic data.

12) Net income.
The net income of the project is calculated as 11) - 10) - 9).

13) NPV.
The net present value of Investment, O&M, Income, and Net income is calculated using the discount rate indicated in 17) below.

14) SUM.
The sum of yearly productions.

15) Internal rate of return for Net income.
The IRR of Net income is found by calling a routine that looks for a discount rate for which the NPV of Net income equals zero. In principle, for some series of payments, more than one discount rate will satisfy this. The discount rate found by the afore-mentioned routine is the smallest positive discount rate less than 200% for which the NPV equals zero, or - if no such positive discount rate exists - the smallest (i.e. closest to zero) negative discount rate between zero and -200% for which the NPV equals zero.

16) Discounted levellized production cost.
This is found as

[NPV(Investment)+NPV(O&M)]/NPV(Production)

where NPVs are found using the discount rate 17).

17) Discount rate.
Discount rate is part of economic data. It is used to calculate the net present values mentioned in 13) and 16) above.

6.2. Cash flow analysis report

Below an example of a cash flow analysis report is shown.

11:21:25. Mar 6, 1991.

Scenario : SCEN Cash flow analysis Current prices.

Year	Installed capacity MW	Installed cap. acc. MW	Amortisation of loans ME	O&M ME	Income ME	Net cash flow ME	N. C. F. Accumulated: ME	Net cash flow ME(1991)
1990	.00	.00	.000	.000	.000	.000	.000	.000
1991	.00	.00	.000	.000	.000	.000	.000	.000
1992	1.50	1.50	.489	.250	.700	-.040	-.040	-.037
1993	.00	1.50	.489	.225	.756	.041	.002	.036
1994	.00	1.50	.489	.194	.816	.132	.134	.105
1995	.00	1.50	.489	.210	.882	.182	.317	.134
1996	.00	1.50	.489	.227	.952	.236	.553	.161
1997	.00	1.50	.489	.245	1.028	.294	.846	.185
1998	.00	1.50	.489	.264	1.111	.357	1.203	.208
1999	.00	1.50	.489	.357	1.199	.353	1.556	.191
2000	.00	1.50	.489	.463	1.295	.343	1.899	.172
2001	.00	1.50	.897	.416	1.399	.086	1.985	.040
2002	.00	1.50	.897	.360	1.511	.254	2.239	.109
2003	.00	1.50	.897	.389	1.632	.346	2.585	.138
2004	.00	1.50	.897	.420	1.762	.446	3.031	.164
2005	.00	1.50	.897	.453	1.903	.553	3.584	.188
2006	.00	1.50	.897	.490	2.056	.669	4.253	.211
2007	.00	1.50	.897	.529	2.220	.794	5.048	.232
2008	.00	1.50	.897	.571	2.398	.930	5.978	.251
2009	.00	1.50	.897	.771	2.589	.922	6.899	.231
2010	.00	1.50	.897	.999	2.797	.901	7.800	.209
2011	.00	1.50	.897	1.259	3.020	.865	8.665	.186
2012	.00	1.50	.407	1.554	3.262	1.301	9.965	.258
2013	-1.50	.00	.000	.000	.000	.000	9.965	.000
2014	.00	.00	.000	.000	.000	.000	9.965	.000
2015	.00	.00	.000	.000	.000	.000	9.965	.000
2016	.00	.00	.000	.000	.000	.000	9.965	.000
2017	.00	.00	.000	.000	.000	.000	9.965	.000
2018	.00	.00	.000	.000	.000	.000	9.965	.000
2019	.00	.00	.000	.000	.000	.000	9.965	.000

The content of the cash flow analysis report is as follows:

1) Time and date of printing.

2) The name of the scenario.

3) The name of the report (Cash flow analysis).

4) Current prices.
Indicates that current prices are used in this report, except for 13) below.

5) Year.

6) Installed capacity.
All wind turbines referenced in the scenario are included taking into account the number of units indicated by the scenario. The capacity of a wind turbines is added in its first year of production and subtracted in the year following its last year of production.

7) Installed capacity accumulated.
This column, which is found by accumulating 6) above, gives for any year the total installed wind power capacity.

8) Amortization of loans.
In the scenario the connections between wind turbines (with an initial investment and possible later reinvestments) and loans are made. The full pay-back period (part of loan data) is used for the initial investment. However, for later reinvestments the pay-back time might be reduced so that all loans due to reinvestments are paid back within the life time of the wind turbine in question. The first instalment is assumed to take place in the year of (re)investment.

9) O&M.
Operation and maintenance costs.

10) Income.
The income from selling the wind generated electricity. The income is calculated from the total yearly production and the price of electricity which is part of economic data.

11) Net cash flow (current prices).
The net cash flow of the project is calculated as 10) - 9) - 8).

12) Net cash flow accumulated.
This column is found by accumulating 11) above.

13) Net cash flow (fixed prices).
The base year of money is indicated in the column heading. This column is calculated from 11) above and the inflation which is part of economic data.

6.3. Economic analysis report

Below an example of an economic analysis report is shown.

11:21:25. Mar 6, 1991.

Scenario : SCEN Economic analysis Fixed 1991-prices.

Year	Installed capacity MW	Installed cap. acc. MW	Investment ME	O&M ME	Capacity value ME	Value of production ME	Net value ME	Accumulated: net value ME
1990	.00	.00	.000	.000	.000	.000	.000	.000
1991	.00	.00	.000	.000	.000	.000	.000	.000
1992	1.50	1.50	3.858	.231	2.122	.643	-1.324	-1.324
1993	.00	1.50	.000	.193	.000	.643	.450	-.874
1994	.00	1.50	.000	.154	.000	.643	.489	-.385
1995	.00	1.50	.000	.154	.000	.643	.489	.103
1996	.00	1.50	.000	.154	.000	.643	.489	.592
1997	.00	1.50	.000	.154	.000	.643	.489	1.081
1998	.00	1.50	.000	.154	.000	.643	.489	1.569
1999	.00	1.50	.000	.193	.000	.643	.450	2.019
2000	.00	1.50	.000	.231	.000	.643	.411	2.431
2001	.00	1.50	1.286	.193	.000	.643	-.836	1.595
2002	.00	1.50	.000	.154	.000	.643	.489	2.083
2003	.00	1.50	.000	.154	.000	.643	.489	2.572
2004	.00	1.50	.000	.154	.000	.643	.489	3.061
2005	.00	1.50	.000	.154	.000	.643	.489	3.549
2006	.00	1.50	.000	.154	.000	.643	.489	4.038
2007	.00	1.50	.000	.154	.000	.643	.489	4.527
2008	.00	1.50	.000	.154	.000	.643	.489	5.015
2009	.00	1.50	.000	.193	.000	.643	.450	5.465
2010	.00	1.50	.000	.231	.000	.643	.411	5.877
2011	.00	1.50	.000	.270	.000	.643	.373	6.250
2012	.00	1.50	.000	.309	.000	.643	.334	6.584
2013	-1.50	.00	.000	.000	.000	.000	.000	6.584
2014	.00	.00	.000	.000	.000	.000	.000	6.584
2015	.00	.00	.000	.000	.000	.000	.000	6.584
2016	.00	.00	.000	.000	.000	.000	.000	6.584
2017	.00	.00	.000	.000	.000	.000	.000	6.584
2018	.00	.00	.000	.000	.000	.000	.000	6.584
2019	.00	.00	.000	.000	.000	.000	.000	6.584
NPV			4.003	1.560	1.929	5.561	1.927	

33.13 % : Internal rate of return for Net value

.21 £/kWh : Wind power production costs (discounted levellized cost)

.29 £/kWh : Avoided costs (discounted levellized cost)

10.00 % : Discount rate

The content of the economic analysis report is as follows:

1) Time and date of printing.

2) The name of the scenario.

3) The name of the report (Economic analysis).

4) The base year of money.

5) Year.

6) Installed capacity.
All wind turbines referenced in the scenario are included taking into account the number of units indicated by the scenario. The capacity of a wind turbine is added in its first year of production and subtracted in the year following its last year of production.

7) Installed capacity accumulated.
This column, which is found by accumulating 6) above, gives for any year the total installed wind power capacity.

8) Investment.
The investments and reinvestments for all wind turbines.

9) O&M.
Operation and maintenance costs for all wind turbines.

10) Capacity value.
When wind power is introduced, the expansion of the conventional thermal power plants can be reduced and thus investments are saved. The capacity factor gives the ratio of reduction of conventional capacity to the capacity of the new wind turbines. In the same way, the expansion of transmission and distribution systems can be reduced. This stems from the fact that wind power plants are often connected to the power grid close to the consumers. Capacity

factors for production, transmission, and distribution systems are part of scenario data.

The reduced expansion of production, transmission, and distribution systems is in the economic analysis report accounted for by the capacity value of the wind power project. In the report the capacity value of a particular wind turbine is included in the first year of production for the wind turbine.

Next, a detailed algorithm for calculation of capacity value is given. The following symbols are used:

	Unit	Conventional power plant	Transmission system	Distribution system	Wind turbine
Capacity factor	kW/kW	cf_plant [1]	cf_trans [1]	cf_dist [1]	
Investments	£/kW	plant_inv [4]	trans_inv [4]	dist_inv [4]	
Life time	years	plant_life [4]	trans_life [4]	dist_life [4]	life [3]
Capacity	kW				cap [3]

sbas [1] (year) : base year for money in the report.

abas [4] (year) : base year for money in avoided costs data.

infl [2] (ratio): yearly inflation.

disc [2] (ratio): discount rate.

cap_val (M£) : capacity value.

1) Part of scenario data.
2) Part of economic data.
3) Part of wind turbine data.
4) Part of avoided costs data.

Using the above defined symbols, the capacity value is expressed as:

$$cap\_val = (cf\_plant*plant\_inv*ann\_plant + cf\_trans*trans\_inv*ann\_trans + cf\_dist*dist\_inv*ann\_dist) * cap * (1+infl)^{sbas-abas} / ann * 0.000001\ M£/£$$

where the following annuity factors are used:

$$ann\_plant = disc/(1-(1+disc)^{-plant\_life})$$
$$ann\_trans = disc/(1-(1+disc)^{-trans\_life})$$
$$ann\_dist = disc/(1-(1+disc)^{-dist\_life})$$
$$ann = disc/(1-(1+disc)^{-life})$$

11) Value of production.

When wind generated electricity is introduced in the power system, the production at the conventional thermal power plants is reduced. This gives rise to a reduction in fuel and O&M costs at the power plants.

Next, a detailed algorithm for calculation of the value of production is given. The following symbols are used:

	Coal	Fuel oil	Diesel oil	Gas
Fuel price [2]	p_coal £/t	p_fuel £/m^3	p_diesel £/m^3	p_gas £/1000 m^3
Heat content [2]	hc_coal GJ/t	hc_fuel GJ/m^3	hc_diesel GJ/m^3	hc_gas GJ/1000 m^3
Fuel mix [4]	mix_coal	mix_fuel	mix_diesel	mix_gas

cf_plant [1] (ratio): capacity factor, regarding conventional power plant capacity.

plant_irv [4] (£/kW) : investments per kW of conventional power plant.

plant_o_m [4] (ratio): yearly O&M costs at conventional power plant specified as a fraction of initial investments.

plant_eff [4] (ratio): effectivity of conventional power plant.

loss_conv [1] (ratio): loss in transmission to consumers from conventional power plant.

loss_wind [1] (ratio): loss in transmission to consumers from wind power plant.

sbas [1] (year) : base year for money in the report.

ebas [2] (year) : base year for money in economic data.

abas [4] (year) : base year for money in avoided costs data.

infl [2] (ratio): yearly inflation.

cap (kW) : capacity of wind turbine.

prod (MWh) : wind turbine power production.

val_prod_fuel (M£) : value of production, reduced fuel costs.

val_prod_o_m (M£) : value of production, reduced O&M costs.

val_prod (M£) : value of production, total.

1) Part of scenario data
2) Part of economic data.
3) Part of wind turbine data.
4) Part of avoided costs data.

Using the above defined symbols, the value of production regarding saved fuel costs is given by:

$$
\begin{aligned}
\text{val\_prod\_fuel} = \text{prod} * (& \text{p\_coal} * \text{mix\_coal} / \text{hc\_coal} + \\
& \text{p\_fuel} * \text{mix\_fuel} / \text{hc\_fuel} + \\
& \text{p\_diesel} * \text{mix\_diesel} / \text{hc\_diesel} + \\
& \text{p\_gas} * \text{mix\_gas} / \text{hc\_gas}) \\
& * 1/\text{plant\_eff} \\
& * (1-\text{loss\_wind})/(1-\text{loss\_conv}) \\
& * (1+\text{infl})^{\text{sbas}-\text{ebas}} \\
& * 3.6\ \text{GJ/MWh} * 0.000001\ \text{M£/£}
\end{aligned}
$$

This formula is used for any year with a non-zero wind turbine power production (prod).

Likewise, the value of production regarding reduced O&M costs in the conventional power production is given by:

$$val\_prod\_o\_m = cap*cf\_plant*plant\_inv*plant\_o\_m*(1+infl)^{sbas-ebas}*0.000001\ M£/£$$

This formula is used for any year from the first to the last year of production for the wind turbine in question.

Finally, the total value of production is given by

$$val\_prod = val\_prod\_fuel + val\_prod\_o\_m$$

12) Net value.
The net value of the project is calculated as 11) + 10) - 9) - 8).

13) Accumulated net value.
This column is found by accumulating 12) above.

14) NPV.
The net present value of Investment, O&M, Capacity value, Value of production, and Net value is calculated using the discount rate indicated in 18) below.

15) Internal rate of return for Net value.
The IRR of Net value is found by calling a routine that looks for a discount rate for which the NPV of Net value equals zero. In principle, for some series of payments, more than one discount rate will satisfy this. The discount rate found by the afore-mentioned routine is the smallest positive discount rate less than 200% for which the NPV equals zero, or - if no such positive discount rate exists - the smallest (i.e. closest to zero) negative discount rate between zero and -200% for which the NPV

equals zero.

16) Wind power production costs.
The discounted levellized cost of production of wind power. Is is found as

[NPV(Investment)+NPV(O&M)]/NPV(Production)

where NPVs are found using the discount rate 18).

17) Avoided costs.
The discounted levellized cost of alternative conventional thermal power production. It is found as

[NPV(Capacity value)
+NPV(Value of production)]/NPV(Production),

where NPVs are found using the discount rate 18).

18) Discount rate.
Discount rate is part of economic data. It is used to calculated the net present values mentioned in 14), 16), and 17) above.

7. EXAMPLE

In this chapter an example of the use of the WEP system is shown. A total input documentation is given together with all three output reports.

The example is realistic for Denmark. The currency "£" used in the tables should be read as Danish kroner (Dkr.).
One US-$ equals 6 to 7 Dkr.

12:48:26. Feb 28, 1991.

Scenario data

Name	:Wind Power Project	
	:	
Economic data	: Economy	
Avoided costs data	: Alternative	
	:	
Base year for reports	: 1990	
	:	
Loss in transmission	:	
to consumers from :	:	
- conv. power plant	: 8	%
- wind power plant	: 5	%
	:	
Capacity factor of wind	:	
power plant regarding :	:	
- production	: 25	%
- transmission	: 15	%
- distribution	: 0	%

Wind power project :

Wind turbine	Number of units	Year of production start	Loan data
First general costs	1	1991	Loan A
95 kW wind turbine	25	1991	Loan A
Second general costs	1	1992	Loan B
180 kW wind turbine	20	1992	Loan B
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	
	0	0	

12:49:15. Feb 28, 1991.

Economic data

Name	:	Economy	
	:		
Base year for prices	:	1990	year
Inflation	:	4.00	%
Discount rate	:	7.00	%
	:		
Heat content :	:		
- Coal	:	24.90	GJ/t
- Fuel oil	:	39.60	GJ/m3
- Diesel oil	:	35.90	GJ/m3
- Gas	:	39.00	GJ/1000m3

Fuel and electricity prices :

Year	Coal £/t	Fuel oil £/m3	Diesel oil £/m3	Gas £/1000m3	Electricity £/kWh
1990	322.98	721.56	1035.66	641.90	.528
1991	331.12	791.47	1136.13	705.67	.531
1992	341.98	851.02	1222.14	769.43	.535
1993	352.83	919.64	1320.28	833.20	.539
1994	363.69	976.60	1401.99	901.21	.543
1995	374.55	1007.68	1446.56	926.72	.547
1996	385.40	1038.32	1490.74	956.48	.551
1997	393.54	1057.30	1518.10	986.23	.554
1998	404.40	1087.51	1561.11	1015.99	.558
1999	415.26	1105.21	1586.91	1045.75	.562
2000	426.11	1135.42	1629.92	1071.25	.566
2001	431.54	1157.42	1661.98	1096.76	.568
2002	439.68	1187.63	1704.98	1126.52	.571
2003	445.11	1207.48	1733.52	1147.77	.573
2004	453.25	1227.34	1761.67	1169.03	.576
2005	458.68	1246.76	1790.21	1186.03	.578
2006	466.83	1266.61	1818.75	1207.28	.581
2007	472.25	1286.46	1846.90	1228.54	.583
2008	477.68	1306.31	1875.44	1249.79	.585
2009	485.82	1326.16	1903.59	1266.80	.588
2010	491.25	1345.58	1932.13	1288.05	.590
2011	497.77	1353.87	1943.86	1296.56	.592
2012	504.28	1362.15	1955.59	1305.06	.594
2013	510.79	1370.44	1967.32	1313.56	.597
2014	517.31	1378.72	1979.05	1322.06	.599
2015	523.82	1387.01	1990.77	1330.56	.602
2016	530.88	1395.21	2002.58	1339.07	.604
2017	537.93	1403.41	2014.39	1347.57	.607
2018	544.99	1411.61	2026.20	1356.07	.609
2019	552.05	1419.81	2038.00	1364.57	.612

12:49:44. Feb 28, 1991.

Avoided costs data

Name	:	Alternative	
	:		
Base year for prices	:	1990	year
	:		
Power plant :	:		
- Investment	:	7190	£/kW
- Life time	:	25	years
- O&M per year	:	3	% of investment
- Effectivity	:	40	%
	:		
- Fuel mix :	:		
- - Coal	:	95	%
- - Fuel oil	:	5	%
- - Diesel oil	:	0	%
- - Gas	:	0	%
	:		
Transmission :	:		
- Investment	:	2400	£/kW
- Life time	:	25	years
	:		
Distribution :	:		
- Investment	:	460	£/kW
- Life time	:	25	years

12:50:13. Feb 28, 1991.

Wind turbine data

Name	:First general costs	
Installed capacity	0	kW
Yearly production	0	MWh
Life time	20	years
Base year for costs	1990	year
Investment	150	k£
- own production	100	%

	Reinvestments		O&M
	Amount	Own produc.	per year
Year	k£	%	%
1	0	0	.00
2	0	0	.00
3	0	0	.00
4	0	0	.00
5	0	0	.00
6	0	0	.00
7	0	0	.00
8	0	0	.00
9	0	0	.00
10	0	0	.00
11	0	0	.00
12	0	0	.00
13	0	0	.00
14	0	0	.00
15	0	0	.00
16	0	0	.00
17	0	0	.00
18	0	0	.00
19	0	0	.00
20	0	0	.00
21	0	0	.00
22	0	0	.00
23	0	0	.00
24	0	0	.00
25	0	0	.00
26	0	0	.00
27	0	0	.00
28	0	0	.00
29	0	0	.00
30	0	0	.00

Year = 1 : Year for initial investment.
O&M : % of initial investment.

12:50:38. Feb 28, 1991.

Wind turbine data

Name	:	95 kW wind turbine	
Installed capacity	:	95	kW
Yearly production	:	226	MWh
Life time	:	20	years
Base year for costs	:	1990	year
Investment	:	780	k£
- own production	:	50	%

	Reinvestments		O&M
	Amount	Own produc.	per year
Year	k£	%	%
1	0	0	.60
2	0	0	.60
3	0	0	1.60
4	0	0	1.60
5	0	0	1.60
6	0	0	2.10
7	0	0	2.10
8	0	0	2.10
9	0	0	2.10
10	0	0	2.10
11	0	0	2.10
12	0	0	2.10
13	0	0	2.10
14	0	0	2.10
15	0	0	2.10
16	0	0	2.10
17	0	0	2.10
18	0	0	2.10
19	0	0	2.10
20	0	0	2.10
21	0	0	.00
22	0	0	.00
23	0	0	.00
24	0	0	.00
25	0	0	.00
26	0	0	.00
27	0	0	.00
28	0	0	.00
29	0	0	.00
30	0	0	.00

Year = 1 : Year for initial investment.
O&M : % of initial investment.

12:51:06. Feb 28, 1991.

Wind turbine data

Name	:Second general costs	
Installed capacity	0	kW
Yearly production	0	MWh
Life time	20	years
Base year for costs	1990	year
Investment	4080	k£
- own production	100	%

	Reinvestments		O&M
	Amount	Own produc.	per year
Year	k£	%	%
1	0	0	.00
2	0	0	.00
3	0	0	.00
4	0	0	.00
5	0	0	.00
6	0	0	.00
7	0	0	.00
8	0	0	.00
9	0	0	.00
10	0	0	.00
11	0	0	.00
12	0	0	.00
13	0	0	.00
14	0	0	.00
15	0	0	.00
16	0	0	.00
17	0	0	.00
18	0	0	.00
19	0	0	.00
20	0	0	.00
21	0	0	.00
22	0	0	.00
23	0	0	.00
24	0	0	.00
25	0	0	.00
26	0	0	.00
27	0	0	.00
28	0	0	.00
29	0	0	.00
30	0	0	.00

Year = 1 : Year for initial investment.
O&M : % of initial investment.

12:51:32. Feb 28, 1991.

Wind turbine data

Name	:	180 kW wind turbine	
	:		
Installed capacity	:	180	kW
Yearly production	:	390	MWh
Life time	:	20	years
Base year for costs	:	1990	year
Investment	:	1030	k£
- own production	:	60	%

	Reinvestments		O&M
	Amount	Own produc.	per year
Year	k£	%	%
1	0	0	.70
2	0	0	.70
3	0	0	1.20
4	0	0	1.20
5	0	0	1.20
6	0	0	1.80
7	0	0	1.80
8	0	0	1.80
9	0	0	1.80
10	0	0	1.80
11	0	0	1.80
12	0	0	1.80
13	0	0	1.80
14	0	0	1.80
15	0	0	1.80
16	0	0	1.80
17	0	0	1.80
18	0	0	1.80
19	0	0	1.80
20	0	0	1.80
21	0	0	.00
22	0	0	.00
23	0	0	.00
24	0	0	.00
25	0	0	.00
26	0	0	.00
27	0	0	.00
28	0	0	.00
29	0	0	.00
30	0	0	.00

Year = 1 : Year for initial investment.
O&M : % of initial investment.

12:52:05. Feb 28, 1991.

Loan data
****

Name	: Loan A	
	:	
Interest rate	:	10 % per year
Term	:	20 years

12:52:25. Feb 28, 1991.

Loan data
****

Name	:	Loan B
	:	
Interest rate	:	8.50 % per year
Term	:	20 years

12:22:01. Feb 28, 1991.

Scenario :Wind Power Project Financial analysis Fixed 1990-prices.

Year	Installed capacity MW	Installed cap. acc. MW	Production MWh	Investment ME	O&M ME	Income ME	Net income ME
1990	.00	.00	.00	.000	.000	.000	.000
1991	2.38	2.38	5650.00	19.650	.117	2.997	-16.770
1992	3.60	5.98	13450.00	24.680	.261	7.189	-17.752
1993	.00	5.98	13450.00	.000	.456	7.243	6.787
1994	.00	5.98	13450.00	.000	.559	7.297	6.737
1995	.00	5.98	13450.00	.000	.559	7.350	6.791
1996	.00	5.98	13450.00	.000	.657	7.404	6.748
1997	.00	5.98	13450.00	.000	.780	7.445	6.664
1998	.00	5.98	13450.00	.000	.780	7.498	6.718
1999	.00	5.98	13450.00	.000	.780	7.552	6.772
2000	.00	5.98	13450.00	.000	.780	7.606	6.826
2001	.00	5.98	13450.00	.000	.780	7.633	6.853
2002	.00	5.98	13450.00	.000	.780	7.673	6.893
2003	.00	5.98	13450.00	.000	.780	7.700	6.920
2004	.00	5.98	13450.00	.000	.780	7.740	6.960
2005	.00	5.98	13450.00	.000	.780	7.767	6.987
2006	.00	5.98	13450.00	.000	.780	7.808	7.027
2007	.00	5.98	13450.00	.000	.780	7.835	7.054
2008	.00	5.98	13450.00	.000	.780	7.862	7.081
2009	.00	5.98	13450.00	.000	.780	7.902	7.122
2010	.00	5.98	13450.00	.000	.780	7.929	7.148
2011	-2.38	3.60	7800.00	.000	.371	4.617	4.246
2012	-3.60	.00	.00	.000	.000	.000	.000
2013	.00	.00	.00	.000	.000	.000	.000
2014	.00	.00	.00	.000	.000	.000	.000
2015	.00	.00	.00	.000	.000	.000	.000
2016	.00	.00	.00	.000	.000	.000	.000
2017	.00	.00	.00	.000	.000	.000	.000
2018	.00	.00	.00	.000	.000	.000	.000
2019	.00	.00	.00	.000	.000	.000	.000
NPV				39.921	6.610	76.554	30.023
SUM			269000.00				

17.25 % : Internal rate of return for Net income

.34 ¢/kWh : Discounted levellized production cost

7.00 % : Discount rate

12:22:01. Feb 28, 1991.

Scenario :Wind Power Project Cash flow analysis Current prices.

Year	Installed capacity MW	Installed cap. acc. MW	Amortisation of loans ME	O&M ME	Income ME	Net cash flow ME	N. C. F. Accumulated ME	Net cash flow ME(1990)
1990	.00	.00	.000	.000	.000	.000	.000	.000
1991	2.38	2.38	2.400	.122	3.117	.595	.595	.572
1992	3.60	5.98	5.221	.283	7.776	2.272	2.867	2.101
1993	.00	5.98	5.221	.513	8.147	2.413	5.280	2.145
1994	.00	5.98	5.221	.654	8.536	2.661	7.941	2.274
1995	.00	5.98	5.221	.680	8.943	3.041	10.982	2.500
1996	.00	5.98	5.221	.831	9.369	3.317	14.299	2.621
1997	.00	5.98	5.221	1.027	9.797	3.549	17.847	2.697
1998	.00	5.98	5.221	1.068	10.262	3.973	21.820	2.903
1999	.00	5.98	5.221	1.111	10.749	4.417	26.237	3.104
2000	.00	5.98	5.221	1.155	11.259	4.882	31.120	3.298
2001	.00	5.98	5.221	1.201	11.750	5.328	36.448	3.461
2002	.00	5.98	5.221	1.249	12.285	5.815	42.263	3.632
2003	.00	5.98	5.221	1.299	12.821	6.301	48.563	3.784
2004	.00	5.98	5.221	1.351	13.404	6.832	55.395	3.945
2005	.00	5.98	5.221	1.405	13.989	7.362	62.757	4.088
2006	.00	5.98	5.221	1.461	14.624	7.941	70.698	4.240
2007	.00	5.98	5.221	1.520	15.261	8.520	79.218	4.374
2008	.00	5.98	5.221	1.581	15.926	9.124	88.342	4.504
2009	.00	5.98	5.221	1.644	16.648	9.783	98.125	4.643
2010	.00	5.98	5.221	1.710	17.373	10.442	108.567	4.766
2011	-2.38	3.60	2.821	.845	10.521	6.855	115.422	3.008
2012	-3.60	.00	.000	.000	.000	.000	115.422	.000
2013	.00	.00	.000	.000	.000	.000	115.422	.000
2014	.00	.00	.000	.000	.000	.000	115.422	.000
2015	.00	.00	.000	.000	.000	.000	115.422	.000
2016	.00	.00	.000	.000	.000	.000	115.422	.000
2017	.00	.00	.000	.000	.000	.000	115.422	.000
2018	.00	.00	.000	.000	.000	.000	115.422	.000
2019	.00	.00	.000	.000	.000	.000	115.422	.000

12:22:01. Feb 28, 1991.

Scenario :Wind Power Project Economic analysis Fixed 1990-prices.

Year	Installed capacity MW	Installed cap. acc. MW	Investment MŁ	O&M MŁ	Capacity value MŁ	Value of production MŁ	Net value MŁ	Accumulated: net value MŁ
1990	.00	.00	.000	.000	.000	.000	.000	.000
1991	2.38	2.38	19.650	.117	4.658	.844	-14.265	-14.265
1992	3.60	5.98	24.680	.261	7.061	2.087	-15.793	-30.058
1993	.00	5.98	.000	.456	.000	2.150	1.694	-28.364
1994	.00	5.98	.000	.559	.000	2.211	1.652	-26.713
1995	.00	5.98	.000	.559	.000	2.267	1.708	-25.004
1996	.00	5.98	.000	.657	.000	2.324	1.667	-23.337
1997	.00	5.98	.000	.780	.000	2.366	1.586	-21.751
1998	.00	5.98	.000	.780	.000	2.422	1.642	-20.109
1999	.00	5.98	.000	.780	.000	2.477	1.697	-18.413
2000	.00	5.98	.000	.780	.000	2.534	1.753	-16.659
2001	.00	5.98	.000	.780	.000	2.563	1.783	-14.877
2002	.00	5.98	.000	.780	.000	2.606	1.826	-13.051
2003	.00	5.98	.000	.780	.000	2.636	1.855	-11.195
2004	.00	5.98	.000	.780	.000	2.677	1.897	-9.298
2005	.00	5.98	.000	.780	.000	2.706	1.926	-7.372
2006	.00	5.98	.000	.780	.000	2.748	1.968	-5.404
2007	.00	5.98	.000	.780	.000	2.777	1.997	-3.407
2008	.00	5.98	.000	.780	.000	2.806	2.026	-1.381
2009	.00	5.98	.000	.780	.000	2.848	2.068	.687
2010	.00	5.98	.000	.780	.000	2.877	2.097	2.784
2011	-2.38	3.60	.000	.371	.000	1.695	1.324	4.108
2012	-3.60	.00	.000	.000	.000	.000	.000	4.108
2013	.00	.00	.000	.000	.000	.000	.000	4.108
2014	.00	.00	.000	.000	.000	.000	.000	4.108
2015	.00	.00	.000	.000	.000	.000	.000	4.108
2016	.00	.00	.000	.000	.000	.000	.000	4.108
2017	.00	.00	.000	.000	.000	.000	.000	4.108
2018	.00	.00	.000	.000	.000	.000	.000	4.108
2019	.00	.00	.000	.000	.000	.000	.000	4.108
NPV			39.921	6.610	10.521	24.806	-11.204	

1.22 % : Internal rate of return for Net value

.34 £/kWh : Wind power production costs (discounted levellized cost)

.26 £/kWh : Avoided costs (discounted levellized cost)

7.00 % : Discount rate

Riso National Laboratory **Riso - M - 2927(EN)**

Title and author(s)

WEP

A WIND ENERGY PLANNING SYSTEM

USER's MANUAL

Helge V. Larsen

Date November 1991

Department or group
Systems Analysis Department
Energy Systems Group

Groups own registration number(s)
ESG 2654-90-6
ESG 02654.00

Project/contract no.

Pages 71 **Tables** **Illustrations** **References**

ISBN 87-550-1727-4

Abstract (Max. 2000 char.) The report describes the Wind Energy Planning system (WEP). It is intended as a decision support system to be used in the economic evaluation of wind energy projects. Such projects could be minor projects with only a single wind turbine or large wind farm projects consisting of several wind turbine plants.

In the WEP system, a wind turbine is described by data on initial investment, possible later reinvestments, O&M costs, expected yearly production, life time, and capacity factor. The raising of loans are modelled, too. Depending on which output report is created, the value of the wind generated electricity is calculated in two different ways: either the electricity is assumed to be sold at a price (time series) given by the user, or the alternative conventional power production is modelled by its specific investment, O&M costs, life time, effectivity, fuel mix, and time series for fuel prices. Using these data, capacity credit and saved fuel and O&M costs are calculated.

Due to the flexible data structure of the model, the user can easily create a scenario that models a large scale introduction of wind power. In such a scenario the gradual build up through several years of the wind power capacity can be modelled.

The report describes in detail the menu structure, the input facilities, the output reports, and the organization of data. Also included is an example with full input documentation and output reports.

Descriptors - INIS/EDB

COMPUTER PROGRAM DOCUMENTATION; COMPUTERIZED SIMULATION; DECISION MAKING; ECONOMIC ANALYSIS; MANUALS; NUMERICAL DATA; PLANNING; W CODES; WIND POWER

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ISBN 87-550-1727-4
ISSN 0418-6435