

# Appendix B: Checklist for choosing BEEM software - completed for ESP-r: July 2002

This checklist complements section 4 of the CIBSE Applications Manual AM11: 1998  
*Building Energy and Environmental Modelling*

## B1 General

### B1.1 Program description

#### Name, vendor, origins

Program name..... **ESP-r**.....  
Version ..... **10.0**.....  
Date of current release ... **July 2002**.....  
Vendor's name ..... **ESRU, University of Strathclyde**.....  
Contact name ..... **Professor J A Clarke**.....  
Vendor's address ..... **Department of Mechanical Engineering**.....  
..... **University of Strathclyde**.....  
..... **75 Montrose Street, Glasgow G1 1XJ**.....  
Tel ..... **+ 44 (0) 141 548 3986**.....  
Fax ..... **+ 44 (0) 141 552 5105**.....  
E-mail ..... **esru@strath.ac.uk**.....

#### Program type

Thermal analysis:

Load calculation  Plant and controls  Energy simulation

Lighting and visualisation:

Electric lighting  Daylighting  Combined

**Note: ESP-r has a link to Radiance for lighting and visualisation studies, and can import Radiance generated data for light-switching studies.**

Air movement

Specialist tool

Further description: **ESP-r is an integrated modelling tool for the simulation of the thermal, visual and acoustic performance of buildings and the assessment of the energy use and gaseous emissions associated with the environmental control systems and constructional materials. In undertaking its assessments, the system is equipped to model heat, air, moisture and electrical power flows at user determined resolution.**

#### Program History

Description **European Reference Model for solar analysis and building simulation. Developed by the Energy Systems Research Unit over the last 25 years with National and EC support.**

## B1.2 Computer specification

### Platform and operating system

PC	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
	MS-DOS	<input type="checkbox"/>	Windows 3.x <sup>®</sup>	<input type="checkbox"/>
	Windows 95 <sup>®</sup>	<input type="checkbox"/>	Windows NT <sup>®</sup>	<input type="checkbox"/>
	PS2	<input type="checkbox"/>	OS2	<input type="checkbox"/>
UNIX <sup>®</sup>	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Apple Mackintosh <sup>®</sup>	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>

Comment .....**Operates on PCs or Workstations under Linux Operating System,  
as well as proprietary Unix operating systems.**

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### Processor, storage and peripherals

Processor speed .....**400 or higher**.....MHz

Minimum RAM .....**128**.....MByte

Minimum disk space .....**100**.....MByte

Other devices:

Floppy disk	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
CD-Rom drive	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Printer	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Plotter	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>
Digitising table	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>

Other .....**Good monitor (at least 19 inch)**.....

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Other requirements .....**Need internet connection to download software**.....

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.....

Suitable machines .....

.....

.....

### B1.3 Program Code

#### Type of Code

Compiled code only	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>
Source code available	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Extra £ for source code	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>
Programming language	FORTRAN	<input checked="" type="checkbox"/>	C/C++	<input checked="" type="checkbox"/>
Notes .....	.....			
.....	.....			
.....	.....			

### B1.4 Modelling methods

See section B2 to document thermal simulation programs.

### B1.5 Input interface

#### Type of interface

GUI	<input checked="" type="checkbox"/>	Menu driven	<input type="checkbox"/>	Command	<input type="checkbox"/>
Other .....	.....				
.....	.....				
.....	.....				

### Digital data file

Program produces accessible and human readable digital data files?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>		
Legibility of digital file	Good	<input checked="" type="checkbox"/>	Poor	<input type="checkbox"/>	Bad	<input type="checkbox"/>
Is entire problem definition contained?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>		
Are all simulation parameters included?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>		

### Data checking

Does program check for consistency and plausibility of input?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
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## B1.6 Output interface

### Type of interface

GUI  Tabular  Digital

### Digital data

Is digital output accessible? Yes  No   
 Legibility of digital file Good  No  Bad   
 Is all output contained? Yes  No   
 Are algorithm level outputs accessible? Yes  No

## B1.7 Linked modules

CAD input Yes  No   
 Vendor's own interface Yes  No

Other CAD systems(s) (name) **AutoCAD, XZIP,  
 MicroGDS (to be implemented soon)**

Comments .....

## B1.8 Associated databases

Thermophysical properties Yes  No   
 Basic material properties Yes  No   
 Properties of complete construction Yes  No   
 Transmission of windows Yes  No

Comment .....

Weather data Yes  No   
 Worldwide Yes  No

Number of sites **TRYs**

Comment: **Can import from other formats**

**(e.g. EPW – joint Energyplus/ESP-r format)**

Other databases (description) **Databases holding timestep (measured) data,  
 pressure coefficients, plant components, event profiles, mould growth data,  
 photovoltaic module data**

## B1.9 User support

### Manuals

User manual	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Hard copy	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
On-line	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Date of the latest copy	N/A.....			
Does it include example problems with the expected answers?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Do the problems exercise all program modules?	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>
Does it explain how to use every module?	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>
Comments .....	<b>Some facilities principally aimed at research community/expert users.....</b>			
.....				
Technical manual	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Hard copy	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
On-line	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
On-line Help *	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Comments: .....	<b>Technical details available on-line at <a href="http://www.esru.strath.ac.uk">www.esru.strath.ac.uk</a></b>			

### Case Studies

Vendor's case study examples obtained?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Case studies of others obtained?	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>

### Hotline

Hotline support	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Turn round	Instant <input type="checkbox"/>	1 day <input checked="" type="checkbox"/>	> 1 day	<input type="checkbox"/>

**Note: ESRU offer support agreements.**

## Software

Updates provided                      Yes        No      
Media for dissemination    Floppy disk        CD        Internet   

## Training

Courses provided                      Yes        No      
Cost                                      £500.....  
Length .....Typically 3 days.....  
Frequency .....3-4 times per year, plus by arrangement on request. ....

## B1.10      User base

### Numbers

Users in UK      **300 estimated**....Users worldwide .....**900 estimated**....  
Sites in UK      **60 estimated.**    Sites worldwide .....**150 estimated**  
UK building services engineers    .....**18**.....  
UK architects                                      .....**3**.....  
UK builders                                         .....**-**.....  
UK others    .....**39**.....  
Is there a user club?    Yes        No   

## Contacts

1.    Name ...      **Professor J A Clarke**.....  
      Address .....  
      .....  
      .....  
      Tel .....**as above**.....  
      Fax ...    **as above**.....  
      E-mail    <mailto:esru@strath.ac.uk>

## B1.11 Cost

### Software and associated databases

Core program	.....	£...../.....
Modules	Name .....	£ .....
	Name .....	£ .....
	.Name .....	£ .....
Databases	Name .....	£ .....
First year user/licence fee	.....	£ .....
<b>Total software and data - Open Source Software.....</b>		<b>£0...</b>

### Computer

Name	...(Approx. P.C. cost)	<b>£1,000</b>
Annual recurring licence fee after first year of use		<b>£0</b>
Typical training course fees per year		<b>£500</b>

## B1.12 Accuracy

Has the program been evaluated?      Yes          No   

Does the vendor exercise routine  
In-house quality testing      Yes          No   

Describe testing regime .....**Regular benchmark testing**.....  
.....  
.....

**COMPLETE THE TABLE BELOW  
TO DOCUMENT  
THE VALIDATION HISTORY**

<b>DATE TESTED</b>	<b>INDEPENDENTLY (I) OR BY VENDOR (V)</b>	<b>TYPE OF TEST A,C,E</b>	<b>SOURCE OF INFORMATION</b>	<b>COMMENTS ON THE RESULTS</b>
2000	I/V	A,C,E	Strachan PA, ESP-r: Summary of Validation Studies	Publication available from <a href="ftp://ftp.strath.ac.uk/Esru_public/documents/validation.pdf">ftp://ftp.strath.ac.uk/Esru_public/documents/validation.pdf</a>

A Analytical verification,

C Intermodel comparison,

E Empirical validation



## B2 Thermal simulation programs: theoretical basis

### B2.1 Conduction and thermal storage

#### Solution method

- Explicit finite difference       Implicit finite difference   
Response factor       Weighting factors   
Other **Finite volume, explicit or implicit (Crank-Nicolson mixed implicit/explicit by default).**

#### Time step length

- User specified       Calculated by program

#### Opaque surface: conduction model

- One-dimensional       Three-dimensional   
**Note: 3-D conduction modelling available**

#### Opaque Layers: node placement

- Fixed at (number)       User specified       Not applicable   
Other .....

#### Glazing: conduction model

- Resistance or  $U$ -value       Multi-layer with nodes   
Other .....

#### Air gaps

- User specified resistance       Program calculated resistance   
Other .....

#### Initial node temperature

- User specified       Program calculated   
Notes .....

#### Preconditioning time

- User specified       Program recommended   
**Note: user can modify recommended value.**

## B2.2 Solar Radiation

### External solar radiation

Direct and diffuse combined	<input type="checkbox"/>	Separate treatment of direct and diffuse	<input checked="" type="checkbox"/>
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### Ground reflection of radiation

Considered	<input checked="" type="checkbox"/>	Not considered	<input type="checkbox"/>
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### Diffuse radiation sky model

Isotropic	<input checked="" type="checkbox"/>	Anisotropic	<input checked="" type="checkbox"/>
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**Note: Perez anisotropic sky model is the default.....**

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### Window transmission – direct

User specified	<input type="checkbox"/>	Program calculated	<input checked="" type="checkbox"/>
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**Note: user specifies angular dependent transmission and absorption properties of glazing systems. Data can be imported from WIS or WINDOW5.**

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### Window transmission – diffuse

User specified	<input type="checkbox"/>	Program calculated	<input checked="" type="checkbox"/>
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Other/Notes .....

.....

### Internal solar distribution

User specified (fixed) to one or more surfaces	<input type="checkbox"/>	Calculated once by program	<input type="checkbox"/>
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Calculated at each time step	<input checked="" type="checkbox"/>
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**Notes: 1.Solar distribution an also be user specified.....**

**2. Retransmission of direct and diffuse to adjacent zones is also calculated.....**

## B2.3 Surface heat exchange

### Internal surfaces

Combined convection and Radiation coefficient	<input type="checkbox"/>	Separate convection and radiation networks	<input checked="" type="checkbox"/>
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### Internal combined coefficients

Fixed user defined  Program calculated once   
Calculated at each time step   
Notes ...N/A.....  
.....

### Internal convection coefficients

Fixed used defined  Program calculated once   
Calculated at each time step   
Notes .....  
.....

### Internal longwave exchanges

Star network  Intersurface exchange network   
Notes ...**Program can calculate internal viewfactors**.....  
.....

### External surfaces

Combined convection and radiation coefficient  Separate radiation and convection networks

### External combined coefficients

Fixed user defined  Program calculated once   
Calculated at each time step

### External convection coefficients

Fixed user defined  Program calculated once   
Calculated at each time step   
**Notes: Coefficient calculated as function of wind speed, wind direction and surface orientation**.....  
.....

### External longwave exchange

User or program calculated  
Coefficient  Detailed algorithm   
**Notes Detailed algorithm employed based on calculation of sky, building and ground components.**

## B2.4 Heating, cooling and casual gains

### Heat input

Combined radiant and Convective  Separate fixed radiant and convective components   
 Notes ...**Both sensible and latent inputs are included.**.....  
 .....

### Cooling

Sensible cooling only  Sensible and latent cooling   
 Notes .....**Moisture content of the air is tracked.**.....  
 .....

### Controlling plant

Free float	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Idealised control	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Ideal preheat/cool	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Fixed heat injection	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
On/off thermostat	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Accelerator	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Proportional	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Proportional plus integral	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Proportional plus integral plus derivative	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Advanced (e.g. fuzzy logic, adaptive, self tuning, neural network)	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Other	..... <b>All possible, user selection.</b> ..... .....			

### Schedules

Repeated daily schedule	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Repeated hourly schedule	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Seasonal variations	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Flexible hourly schedule	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Notes	..... .....			

## Sensor types

Sensing air temperature	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Mixed radiation and convection sensing	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Surface temperature sensing	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
Notes .....				
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## B2.5 Observations

1. Program subjected to validation studies and scrutiny over life-time of development. Report cited on B1.12 summarises work done on ESP-r by both in-house and independent validation studies.
2. Technical details of the program are available in Clarke J A *Energy Simulation in Building Design*, Butterworth Heinemann, Oxford, 2001. In addition, detailed technical background is available in a number of PhD theses available at <http://www.esru.strath.ac.uk>.
3. The website also contains details for downloading the software, together with case studies, training information, tutorial, self-learning exercises, frequently-asked questions etc.