The Australian Nationwide House Energy Rating Scheme

A Progress Report

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INTRODUCTION

The Australian Nationwide House Energy Rating Scheme arose as a result of a commitment by Commonwealth, State and Territory governments to improve the energy efficiency of buildings. The objectives of the scheme are:

- to assist the public and the building industry to identify the extent to which a new or existing house has the potential , through its design and construction, to be of high efficiency in its use of space heating and cooling energy;
- to facilitate rating of the thermal efficiency of dwelling design and construction, in a manner that is nationally coordinated and consistent, and is regionally sensitive to variations in climate, housing design and other factors.

Although there have been previous attempts to develop such schemes in Australia, this is the first adequately-funded nationwide initiative of this type. The scheme has been undergoing development since 1993, when Professor John Ballinger, of the School of Architecture, was appointed Project Manager through UNISEARCH, University of New South Wales.

SCOPE OF THE SCHEME

As well as the very common detached single-family houses, the scheme will also encompass medium-density housing developments as well as low-rise apartment buildings (the last two are undergoing something of a boom at present in the inner suburbs of some of our major cities). It should be noted in passing that the energy efficiency of other building types, such as office towers, will be dealt with by the Building Energy Code of Australia, which is also currently under development.

At this stage, the NatHERS scheme does not include the efficiency of household appliances (e.g. hot water systems), nor the efficiency of the heating and cooling plant itself. That is, it concentrates on the efficiency of the building envelope, assessed in terms of space heating and cooling energy requirements. Appliances and plant efficiency may be included in the future.

The scheme will be applied Australia-wide. This imposes its own set of problems, owing to the very wide range of climates that must be accommodated, ranging from alpine to hot-humid. A consequence of this is the wide range of heating and cooling patterns, and more importantly, the fact that in some locations heating and cooling is not normally needed or used. While the rating scheme software now deals with unconditioned buildings, ratings issues for these cases are still to be addressed.

Dwellings will be rated on a scale of 0 to 5 stars. In recognition of the fact that this is a joint Federal/State initiative, the actual implementation of the scheme will be the responsibility of individual States, subject to consistency requirements.

TECHNICAL BASIS

It was decided quite early in the development process that the rating would be based on computer simulation of the building, using hourly calculations over a full year. The CHEETAH package, developed by the CSIRO Division of Building, Construction and Engineering, was chosen as the basis of the simulation tool (CHEETAH was one of the programs that participated in the recent IEA Task 21C/12B empirical validation exercise). To satisfy the needs of the scheme, CHEETAH underwent considerable development and enhancement. The resulting software package is called NatHERS.

The front-end

CHEETAH's DOS-based front-end was replaced by a Windows-based front-end using Borland's Object-Vision software. An early version had originally been developed by the Gas and Fuel Corporation of Victoria as a front-end to CHEETAH's simulation engine, and was therefore able to be modified quickly to meet the tight deadline for this phase of the development.

Data entry is via four main screens or forms: a Main form, which contains the basic job details and gives access to the other forms (Figure 1); a Construction form, which allows the user to select a main and two alternative constructions for the windows, walls, floors, etc from drop-down lists (Figure 2); the Dimensions form, in which lengths and/ or areas are entered for the various elements on subsidiary zone forms; and a General form, in which information about infiltration and the potential for cross-ventilation is entered via simple Yes/No responses. Information about indoor and outdoor user-operable shading devices, and fixed shading from overhangs, pergolas and other buildings, is also entered in these forms.

The current front-end deliberately restricts the full flexibility of the simulation engine in the interests of keeping the data input requirements to a minimum. For example, only four habitable zones are allowed: Living, Bedroom, Other Conditioned (which must be classified as a type Living or Bedroom), and Unconditioned (e.g. laundries, attached garages and other service areas). Roofspace and sub-floor zones are formed automatically (if necessary). Similarly, because its primary purpose is as a rating tool, there is no provision for the user to change the data for occupant behaviour, e.g. times of heating and cooling, and operation of curtains, external blinds, and windows.

While the current front-end is adequate, it is clear that the choice of software has imposed some limitations and difficulties that we could all do without. Thus it is intended to replace the existing front-end by a much better version within a year or so.

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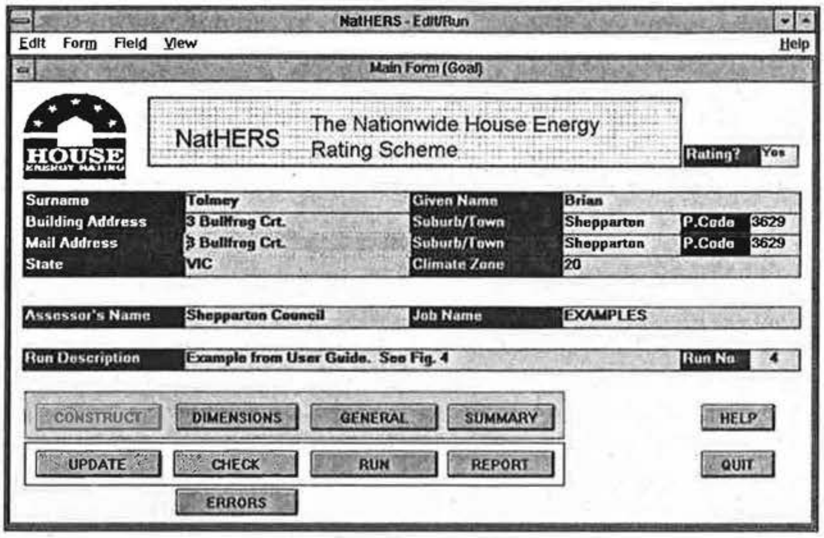

Figure 1 Main Form - Job Details and Menu

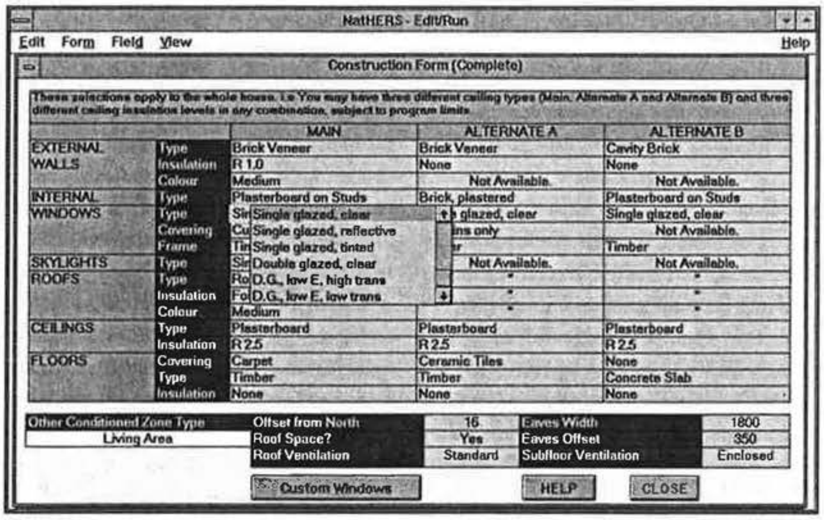

Figure 2 Construction Form - Select Constructions

The Simulation Engine

The CHEETAH simulation engine is based on the zone response factor method, which in turn is based on analytical solutions of one-dimensional heat flow through multi-layer building elements with constant properties. For the NatHERS development, the engine was enhanced in a number of ways. The most important were:

- An improved glazing model. The original engine used the shading coefficient concept to model any glazing other than clear single glazing. The new model directly uses data on the overall transmittance, and absorptance of each pane, as a function of angle of incidence, to calculate solar heat gains. Outdoor convective heat transfer coefficients are calculated from a correlation developed from the recent MoWitt measurements for low-rise glazing in the USA. This correlation depends on local wind speed and surface temperature. Interestingly, it yields considerably lower convective coefficients than have been used by some simulation programs. The modelling of the window frame is also improved, taking into account its area, solar absorptance as a function of angle of incidence, and *U*-value (but not its thermal capacitance).

  The new glazing model allows the NatHERS software to offer the user a list of six glazing types (three single glazings and three double glazings) and three frame types (aluminium unbroken, aluminium broken, and timber/PVC). Future developments will allow custom glazings to be simulated.
- An improved model of heat flow from concrete slab-on-ground floors. This is based on my mathematical model of steady-state and time-dependent slab heat flows, developed over a number of years and refined by others. However edge insulation is not yet included.
- Simultaneous heating and cooling in up to three zones. Unlimited heating and cooling capacity is assumed and inter-zonal heat flows are taken into account simultaneously, so that any combination of thermostat settings is always achieved at the end of each hour. While this precision is recognised as being rather unrealistic, it is useful for ratings purposes.

Output Reporting

The reporting facility produces several simple output screens. The main screen gives a brief building description, and the annual total heating, sensible cooling and latent cooling energy requirements for the conditioned zones (in MJ/m^2 of conditioned floor area). If appropriate it also shows the star rating for the building, which is calculated from the energy total (Figure 3). When the building is run in rating mode, the Living, Bedroom and Other Conditioned (if it exists) zones are automatically conditioned and a star rating displayed. If the building is run in non-rating mode, the user can choose to heat and/or cool any or none of these zones. Energy totals are still displayed, but a star rating is not given.

Two other output screens are available, which give information about the temperatures in the zones. The user can configure the temperature reports by choosing the months or seasons of interest (the latter being user-definable), the zones, and, for each zone, the times of interest (e.g. waking or sleeping hours, or any sub-set of the 24 hours), and the upper and lower limits of the comfortable temperature range. The degree hours screen then gives the number of underheating and overheating degree hours for each zone chosen. The overheating degree hours are simply the cumulative difference between the zone temperature at each hour and the specified upper limit of the comfort range (whenever this is positive) for the chosen times and period. Underheating degree hours are defined similarly. Finally, the temperature information can be displayed as histograms of occurrences of temperatures in 1-degree bins, for the chosen zones, hours and period. Bars below the lower comfort limit are coloured blue, those within the comfort range are coloured green, while those above the comfort range are coloured red (Figure 4). If ceiling fans were chosen in a zone, the upper limit of the comfort range is increased by 3 degrees, which is an estimate of the effect of such fans on the apparent temperature.

The temperature information screens were developed as a first attempt to cater for warm-humid climates, where houses may be completely unconditioned. However, a method for deriving a star rating from temperature information for an unconditioned house has not yet been developed.

Weather Data

Hourly weather data (dry and wet-bulb temperature, wind speed, cloud cover and direct and diffuse solar radiation) for one year is required for the NatHERS software. The key problem is solar radiation. Solar radiation measuring stations are very sparse in Australia, and only 59 sites were available that contained sufficient data; even then for some sites the solar data was estimated from cloud cover and other parameters. A study of the problem of determining a suitable weather data set for every location in Australia showed that 28 sites could be used to adequately cover the country. Each postcode is associated with one of the 28 data sets. Long-term average data, simulation of building performance, and any other relevant information was used to determine the association where hourly data were not available. Some postcodes cover a very large area, and may straddle two or more climate zones. These have two or more data sets associated with them, one of which must be selected by the user. The relevant weather data file is automatically called up when the user enters the building's postcode on the main input data form.

Validation

As part of the development process, the enhanced CHEETAH engine (now known as CHENATH) underwent two specific validation exercises. The first was a repeat of the above-mentioned IEA Empirical Validation exercise (admittedly in non-blind mode). Initially the objectives were simply to check that the enhancements had not introduced errors into the program, and to further investigate areas of difficulty identified by the IEA results and report. As this work progressed, the new glazing model became available, and so this was compared with the old model. The exercise proved to be very useful: some of the problems that had been experienced with CHEETAH were simply due to differences in timing conventions between CHEETAH and the measurements (a common pitfall!), which disappeared when a new and more detailed method was developed to account for the

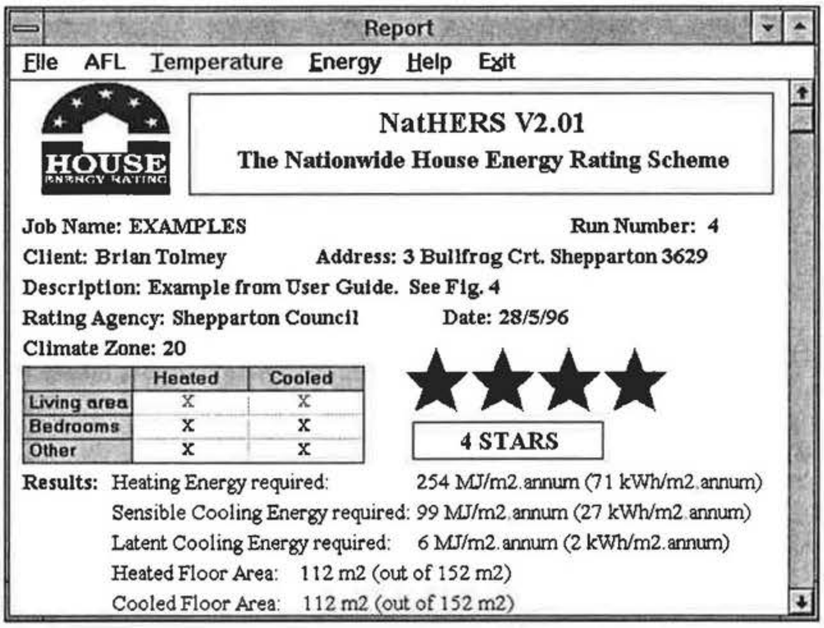

Figure 3 Main Form - Star Rating

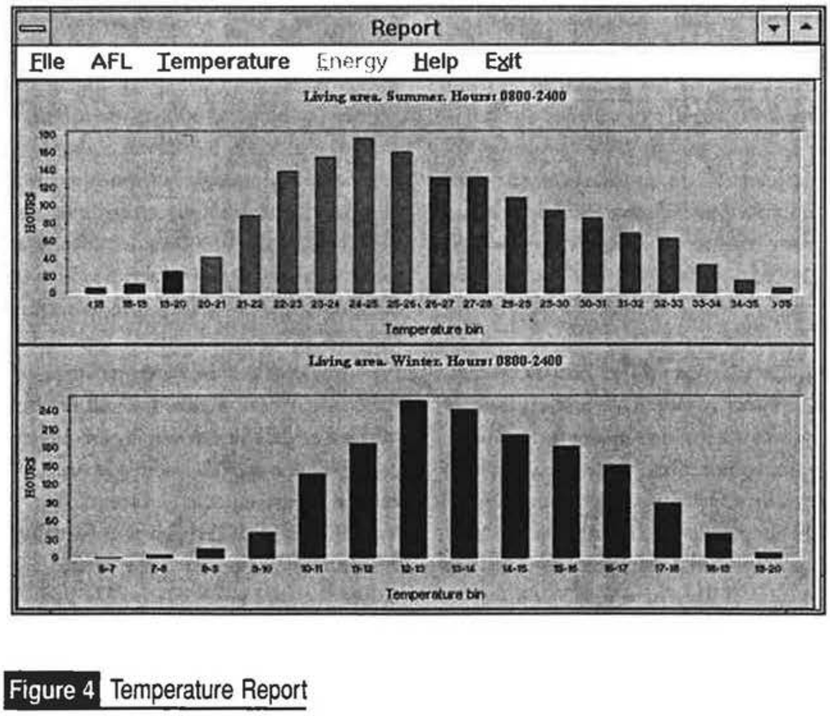

Figure 4 Temperature Report

differences. The comparisons also suggested that no new errors had been introduced. Finally, the new single-glazing model performed much better than the old in terms of free-running temperature predictions, and it was clear that the improvement was largely attributable to the lower convective heat transfer coefficients.

For the second exercise, CHENATH was put through the IEA BESTEST procedure, which was also very useful. No major errors could be detected. However, CHENATH consistently overpredicted annual cooling energy and peak heating and cooling demands. This was almost certainly attributable to the fact that the program calculates and controls an environmental temperature, not a pure air temperature. Further analysis of the results showed, encouragingly, that its prediction of percentage changes from a base case always agreed very well with the reference programs.

IMPLEMENTATION ISSUES

At present the NatHERS software does not convert annual energy requirements to a star rating, since this is still a subject of negotiation between the States and Territories. One of the problems with using absolute energies to determine star bands is that they become outdated as the software is improved or just changed (for example, if thermostat settings are changed). One proposal under consideration is to use relative values, by comparing results for a particular house to those obtained for a reference house using the same simulation program.

While the NatHERS software is the reference software for the scheme, it is not intended to be the only software that can be used to issue ratings. Other programs will be able to be used, provided that they have been accredited. The accreditation process is currently under development, and is likely to be based on the BESTEST concept. One example of other software already available is that developed by the Victorian Government, who developed their HERS before the Nationwide scheme. Their software is based on a points score system, whereby each building component is assigned a certain number of points, which are calculated from correlation equations between heating and cooling energy and building characteristics. These equations were distilled from many CHENATH runs of variations on a prototypical house. The aggregate points are then used to determine the star rating. The advantage of this system is that the calculation is instantaneous. The disadvantages are that it is less accurate, and tends to get out of step with the simulation engine as the latter is progressively improved.

CONCLUSION

The wide range of climates and patterns of heating and cooling found in Australia present a significant challenge to the development of a truly nationwide house energy rating scheme. Although some technical and administrative issues still remain to be resolved, considerable progress has been made over a short period of time. The next year or so should prove to be very interesting.

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A New User Interface for HTB2

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HTB2, a general purpose model for the simulation of energy flows and environmental conditions in buildings, will be re-released with a new PC/ Windows interface later this year. HTB2 has been thoroughly tested in IEA Annex 21 and other model comparison and validation exercises, and is well established within the research community in the UK. The new interface described in this paper will strengthen its exist-ing user base and make it more attractive for use in education and practice.

HTB2 is a multi-zone model capable of dealing with problems involving complex fabric, ventilation, services and occupancy. It can produce detailed output, at variable time and data rates, and is simple, flexible and extendible.

The core program is a descendent of research codes dating back to the mid '70s. The original HTB model was a simple finite difference model, but its capabilities have been progressively revised and extended. HTB2, released in 1985, made a major step forward in programming and documentation standards, as well as in functionality. In HTB2 the finite difference time slicing approach led to a simple framework in which each component could be isolated, but still fully featured. This was used to simplify the coding of the model, leading to an easily maintained and updated program.

HTB2 is aimed largely at research and education users; its structure is flexible, easily understood and modifiable. The detailed data structures allow the user to investigate both the operation of a particular feature, such as a thermal storage element, and the interactions of features, such as the effect of heating system types on the energy characteristics of a passive solar house design.

The new interface makes HTB2's power much more accessible. The PC package requires Windows 3.1 (or Windows95) and a DX386 or better processor. The software will be made available as a standalone program suite, or on request as a SDK with libraries and/or source code included. The core calculation engine is portable and has been tested on many platforms, ranging from 16bit PCs through to mainframe super-computers.

The fabric modelling facilities, summarised in figure 1, allow the thermal performance of building elements to be studied both in space and in time.

The flexibility of the heating system descriptions allow the system characteristics of a number of common systems to be

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emulated (figure 2)

The structure of HTB2 makes it easy to alter or to add new functionality: there are linkage points for external users' code within the calculation stream and data structures. These provide workbench access for testing and refining new algorithms or procedures. More fundamental changes in the code can also be undertaken; external users have linked HTB2 to other simulation software such as HVACSIM+ (a fully feature plant simulation) and ESL (a general simulation language). In these cases, HTB2 has become a module of the larger overall simulation, handling the calculation of the building components.

Despite all this flexibility HTB2 has remained conceptually simple. This has been a strength in research applications and makes the model particularly suitable for use in teaching. The recently developed Windows interface provides ease of use that was not possible in a text driven environment and makes it possible for undergraduates to start making effective use of powerful dynamic simulations very quickly.

The *Scheme* and *Construction* editors allow the creation and modification of building descriptions.

The *Scheme* editor (figure 3) highlights the underlying thermal network rather than the physical appearance of the design. This forces designers to consider their design in thermodynamic components. The *Construction* editor allows composite elements such as walls to be created, either from scratch or by editing standard types from a library, using a simple display of the properties of their components.

The *Run Monitor* (figure 4) facilitates control and monitoring of the simulation calculations. It provides a view into the calculation results as they proceed, through configurable strip-charts. This allows both the validity of a simulation to be verified, and the development of insight into the operation of the simulated building.

A *Data Viewer* allows the extraction and translation of HTB2 calculation results. As well as simple printout and graphic views of results, the Data Viewer exports data to other more complex analysis or reporting software.

HTB2 is used as a demonstration and teaching medium within the Welsh School of Architecture in both the undergraduate and postgraduate courses. Developments to the new interface provide "real-time" views of the effect and interactions of thermal mass, solar gains, shading and occupancy regimes. The model has few constraints on the input problem. As a result it is possible to move from a simple tutorial visualising the temperature and heat flows in an isolated wall that result from a periodic fluctuation in "external" temperature, through to a full simulation of the environment conditions within an office block, within the same programme.

The enhanced functionality and ease of use provided by a Windows interface opens new doors in the preparation of demonstration material. This applies not only within a University environment but also in practice, where targeted Computer Aided Teaching courses using simulation to explore the thermal issues arising in passive solar design, solar shading, ventilation etc. can be prepared to develop practitioners' professional skills as well as their designs.

For further information about HTB2 please contact Don Alexander.

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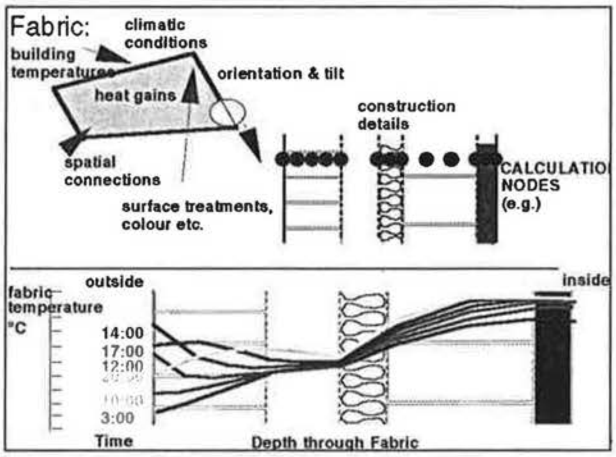

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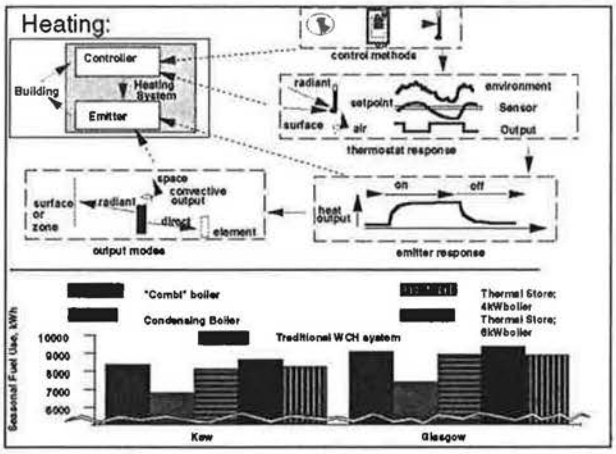

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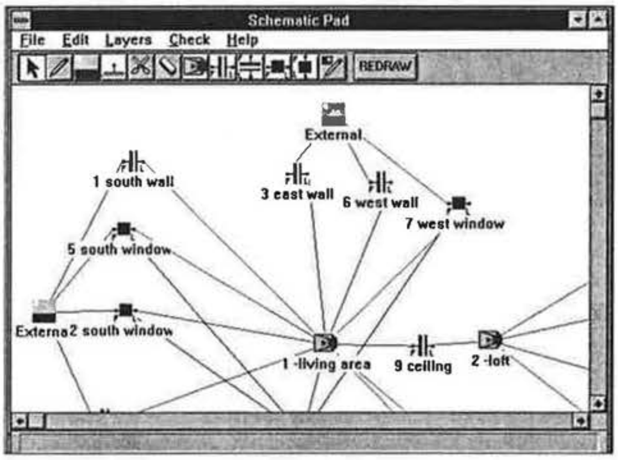

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