Electric Load Forecasting in a Hydro- and Renewable Based Power System

Egill Benedikt Hreinsson
School of Engineering and Natural Sciences,
University of Iceland, Hjardarhagi 6, Reykjavik, Iceland
Email: egill@hi.is

Abstract—Electric load forecasting has for decades been an integral part of power system planning, including renewable hydro based system planning. In this paper we present load forecasting in the renewable based power system of Iceland. When load forecasting was initiated, informal forecasts were made by utility companies, especially before and after establishing the main generating company, Landsvirkjun in 1965. However, in 1976, a dedicated Energy Forecasting Committee (EFC) was established by the stakeholders to carry out coordinated, system wide forecasts of annual electric load. The paper reviews the history and practice in these forecasts and, in addition, adapts them to renewable system needs, by expanding them to include different time frames, and suitable calendars for annual, weekly and hourly system wide time frames. This is done by interpolation in weekly and season-specific hourly distribution factors, from generic factors published and estimated by the EFC. The results of this paper include a load forecasting framework, applicable in three time frames and various types of power system planning and operations models. The modeling approach presented here constitutes a coordinated hierarchy with annual load forecasts at the top, then a medium term weekly model and a short term, hourly load model at the bottom of the hierarchy. These modeling approaches can be used interactively in power system modular planning and operations models.

I. INTRODUCTION

In this paper we present electric load and energy forecasting methods and practices in the Iceland power system, especially in the period from the founding of the official Energy Forecasting Committee (EFC) approximately 40 years ago, i.e. in 1976, until today. In addition, we expand the model and methods presented by the EFC in its reports [1, 2, 3, 4] to include a comprehensive weekly and daily time resolution, adapted to a calendar model, well suited for power system planning and modeling.

The purpose of the paper is, therefore, to define useful load modeling frameworks or load forecasts, suitable for hydro-based system planning. In particular, we investigate the following types of models:

- First, we make a comprehensive long term load model with *annual time resolution*, well suited for hydroelectric expansion studies, using a *water year*, instead of a calendar year, as a time increment, as discussed further below.
- Secondly, a medium term load modeling framework is presented with *weekly time resolution* useful in common long term operations studies and well suited for hydroelectric optimization models, such as those based on LP (Linear programming) or SDDP (Stochastic dual dynamic programming) [5], to name two well known methods, but also compatible with the above annual model.
- Finally, a short term load modeling framework with *hourly time resolution* is set forth, useful in short term operations studies and well suited for short term system operations and optimization with daily load fluctuations, and also consistent with the above medium and long term models.

As opposed to, for instance [4], we present a model accounting for a full 365 day year (52 weeks + 1 day), but in order to suit a flexible planning objective, leap years are ignored in the models of this paper.

The paper is organized as follows:

- In Section II we review briefly the history of energy forecasting by the EFC, and introduce the modeling expansions with a comprehensive load model.
- In Section III we present numerical cases for Section II with forecasts, both annual, weekly and hourly, and present in numerical and graphical form.
- In Section IV we present discussion of these methods regarding the applicability of the results in power system modeling. Also, the main conclusions of the paper are provided with possible extensions.
- Finally the paper is concluded with acknowledgement and references sections.

II. ENERGY FORECASTING AND THE EFC

First, a review of forecasting by the EFC is presented in the next sub-section.

A. Basic review of load forecasting in Iceland

As stated on the EFC’s home-page [1], the EFC is a forum of establishing forecasts for the major power companies, institutions and associations in the electric power industry in Iceland. The members of the EFC are appointed by these organizations, in addition to members from the Statistics [6] and Registers Iceland [7] as well as the Ministry of Finance. The EFC has been working on forecasting since 1976, and presently it has 3 working groups, which cover (a) electricity, (b) geothermal and (c) fuel based energy forecasting.
Each of these groups prepares forecasts in its own field, while the committee defines the basic assumptions and coordinates the overall effort. In this paper we focus exclusively on electric load/energy forecasting.

Since its founding, the EFC has published about eight (8) electric energy forecasts [4]. However recalculations of earlier forecasts, based on changed assumptions have been carried out almost every year since the beginning. The first forecasts were in 1977 and 1978; these were practically the same forecast. Another important one dates back to 1985. The most recent forecast is from December 2015 [4], when this paper was being written, but the one before that was published in 2010 [2], with recalculations every year after that, for instance [3]. The 2010 forecast [2], therefore provides the important data for this paper, with the forecast itself, distribution factors, etc.

Figure 1 compares these long term forecasts graphically, showing actual load and reviews how well these forecasts have done in retrospect. Early on, the forecasts turned out much too high, but since 1985, as the Figure indicates, the forecasts have been more successful. Figure 1 includes the recent forecasts from 2010, [2] but not the 2015 forecast [4].

**B. The EFC forecasting assumptions and methods**

The main EFC assumptions and methods are now described, regarding the EFC electric energy forecasts and models. The forecasts are made based on the general residential and light industry demand and are extended to the year 2050. They assume both firm energy and interruptible contracts with a breakdown into the main regions of Iceland, in addition to forecasting the composite demand for the whole country. The forecasts are based on assumptions on number of households, population, gross domestic product and the production of individual sectors of the economy. The load is decomposed into six categories, in addition to accounting for transmission and distribution losses. For energy intensive industry (EEI) the forecasts take into account the present contracts with EEI. And they are also based on average temperature measurements for the period 1951 to 2005.

The results and methods of the EFC are not load models in the sense econometric, mathematical forecasting models. They are based on forecasts set forth by the EFC on different subcategories of the load and then summed to make a total from these categories [4]. Just to name an example from [4], page 4.19 in the case of the subcategory of electric cars:

“...The energy consumption of electric cars is estimated 20 kWh/100 km in 2015 and should increase to 25 kWh/100 km in 2030, since electric cars will likely first replace smaller cars, but larger cars will be more common later with higher energy use per km. The development in electric cars should lead to a slightly diminished energy consumption, assumed to become 23 kWh/100 km in the year 2050....”

In broad terms, the results include a projection, where the demand is expected to increase by 18% until the year 2020 and by 97% for the next 36 years or until 2050. The annual increase is expected to be approximately 1.9% [2, 3, 4].

**C. Loads and markets**

"Orkuspárfnnd" or the EFC operates within the Icelandic National Energy Authority [8] and recent publications are [2, 3] in addition to [4]. As previously noted, the EFC usually makes forecasts several decades into the future and it forecasts both annual power peak and annual energy loads in a calendar year. Therefore the annual forecasts are represented by time series based on the period January - December, each year.

**D. Water years and calendar years.**

Although the forecasts by the EFC are made for a calendar year (January-December), in hydro-based system planning a more practical annual unit for planning purposes is often what is called a water year (September-August). This stems from the dynamic nature of the system seasonal reservoirs which start to fill up in the fall, i.e. the beginning of the water year. Then the critical point in reservoir operation occurs in the winter period with continuous operation of reservoirs from, say, November to April. This is the reason why a practical unit in planning has traditionally been chosen as the water year as opposed to the calendar year.

To convert to a water year, we start by calculating the annual energy demand $D_y$ for water year number $y$ from a time series $D_c^y$ for a calendar year. To do this, as accurately as possible from the EFC specifications, we form an annual time series $D_y$ with weighted averages from adjacent elements in the series $D_c^y$. A numerical example of this is shown in Column 10 of Table I later in the paper and will be discussed later.

To formalize a load model based on different time frames for a water year, we start by defining $y = 1, 2, ... y_{max}$ to be an index for either water or calendar years in the time series, where $y_{max}$ is the length of the planning horizon. Let $D_{cy}$ be the annual calendar year load in GWh/year. Therefore, a time series for calendar year load $D_{cy}$ is assumed to be known. Furthermore, let $D_{cy1}$ be the load in Interval 1, defined as the months January to end of August and let $D_{cy2}$ be the load in
Interval 2, that is from the beginning of September to the end of December. Furthermore, let \( \rho_1 \) be the fraction of the annual load occurring in Interval 1 and \( \rho_2 \) be the fraction in period 2, where \( \rho_1 + \rho_2 = 1 \). We assume that \( \rho_1 \) and \( \rho_2 \) do not change form year to year. Finally let \( \vartheta_y \) be the growth factor for the load in \( D^c_y \) from previous calendar year, that is

\[
D^c_{y+1} = \vartheta_{y+1} D^c_y
\]  

(1)

First, of course, the sum of loads in the two periods equals the annual load, or:

\[
D^c_y = D^{c1}_y + D^{c2}_y
\]  

(2)

The load in each period is the given fraction of the annual load, or:

\[
D^{c1}_y = \rho_1 D^c_y \quad \text{;} \quad D^{c2}_y = \rho_2 D^c_y
\]  

(3)

As \( D_y \) is the annual load in a water year, we define it as the sum of loads in the 2nd period in the year \( y \) and the 1st period in the year after \( y + 1 \), or:

\[
D_y = D^{c2}_y + D^{c1}_{y+1} = \rho_2 D^c_y + \rho_1 D^c_{y+1} = (\rho_2 + \rho_1 \vartheta_{y+1}) D^c_y
\]  

(4)

Therefore, of course, from (4), the load in a water year \( D_y \) is the weighted average of the load from two consecutive calendar years. Assuming a constant \( \vartheta_{y+1} \) it is also a given fraction \( \rho_2 + \rho_1 \vartheta_{y+1} \) of a calendar year’s load.

Later in the paper numerical examples are given. Therefore, from column 3 in Table I we have the average growth rate as follows:

\[
\vartheta_2 = \ldots = \vartheta_{i+1} = \ldots = \frac{\sqrt[35]{6317}}{3574} = \sqrt[35]{1.767} = 0.0164
\]  

(5)

To calculate values for \( \rho_1 \) and \( \rho_2 \), we need a description of how the load is distributed within a calendar year, such as weekly distribution factors. These are discussed in the next subsection.

E. Weekly load distribution for water- and calendar years

We start by defining \( \varrho^i_1, \varrho^i_2, \ldots, \varrho^i_52 \), as distribution factors for the 52 weeks of the calendar year. For numerical examples of such factors, see Table III in the next section, where the data on distribution factors are from [2]. Furthermore, assuming a 365 day year, an extra day is added to one week, (Since 365 \( - 7 = 364 \)) making it an 8 day week. For a calendar suitable for general planning purposes, with uniform years into the future, leap years and holidays are ignored. Note that a 365 day year, instead of a 364 year, eliminates an error of 1/365 = 0.37% between an annual and a weekly model.

Now define \( D^c_{w,y} \) as the weekly load for week \( w \) of the calendar year \( y \) and, similarly, let \( D^c_{w,y} \) be the weekly load for week number \( w \) of the water year. Note that counting of weeks starts at different times of the year, that is \( w \) starts at January 1st (Week 1) and \( w \) starts at September 1st, occurring in week \( w = 35 \). Incidentally, we choose the 8 day week to be week number 35 of the calendar year. It is convenient later to split it up to meet the start of the water year. This is because the week has to be split, anyway to meet the requirements for a water year calendar starting on September 1st.

Then we have, by definition, for a calendar year:

\[
\vartheta^c_w = \frac{D^c_{w,y}}{D^c_y}
\]  

(6)

From (3), for calendar year \( y \), by splitting the 8 day week number 35 into a 5 day part with load \( D^c_{35a,y} \) and a 3 day part with load \( D^c_{35b,y} \) we get:

\[
D^c_y = D^c_{1,y} + D^c_{2,y} + \ldots + D^c_{34,y} + D^c_{35a,y} + D^c_{35b,y}
\]  

(7)

This splitting is indicated by the dates shown in Table III in the next section. Therefore from (3), (6) and (7), we have

\[
\rho_1 = \varrho^1_1 + \varrho^1_2 + \ldots + \varrho^1_{34} + \varrho^1_{35a}
\]  

(8)

\[
\rho_2 = \varrho^1_{35b} + \varrho^1_{36} + \ldots + \varrho^1_{51} + \varrho^1_{52}
\]  

(9)

Now (8) and (9) are substituted into (4) and we get:

\[
D_y = (\varrho^1_{35a} + \varrho^1_{36} + \ldots + \varrho^1_{52} + \vartheta_1 \varrho^1_1 + \ldots + \varrho^1_{y+1} \varrho^1_{35a}) D^c_y
\]  

(10)

Therefore we get:

\[
\frac{(\varrho^1_{35a} + \varrho^1_{36} + \ldots + \varrho^1_{52} + \vartheta_1 \varrho^1_1 + \ldots + \varrho^1_{y+1} \varrho^1_{35a})}{(\rho_2 + \rho_1 \vartheta_{y+1})} = 1
\]  

(11)

Next, define the weekly distribution factors \( \varrho_i \) for period number \( i \) in a water year (No superscript), where \( i \in \{35b, 36, ..., 52, 1, 2, ..., 35a\} \), and similarly to (6), we get:

\[
\varrho_i = \frac{D^c_{i,y}}{D^c_y}
\]  

(12)

From (10), (11) and (12), therefore, we have the definition in (13) for the distribution factors \( \varrho_i \) for water years, in terms of the corresponding factors (\( \varrho^c_i \)), assumed known for a calendar year.

\[
\varrho_i = \frac{D^c_{i,y}}{D^c_y} = \left\{ \begin{array}{ll}
\frac{\vartheta_{y+1} \varrho^c_i}{\rho_2 + \rho_1 \vartheta_{y+1}} & \text{if } i = 1, 2, ..., 35a \\
\frac{\vartheta_{y+1} \varrho^c_i}{\rho_2 + \rho_1 \vartheta_{y+1}} & \text{if } i = 35b, 36, ..., 52
\end{array} \right.
\]  

(13)

The denominator in (13) comes from the last part of (4), while the nominator is from the elements of the sum in (10). Therefore \( \varrho_w \) depends on the distribution factor for the calendar year \( \varrho^c_i \), the annual growth rate \( \vartheta_{y+1} \) of the calendar year series \( D^c_y \) and the constant weights between interval 1 and 2, that is \( \rho_2 \) and \( \rho_2 \).

However finally, to get (12), we still have to allocate these factors to the 52 weeks of the water year, where one week would be 8 days long and the others 7 days long.
F. Rescheduling for water years

It is clear that the periods of the year in (13) are not equally long. As described above, and counting from September 1st, the first period of the water year \( w' = 1 \), is 3 days long and the last one is 5 days long (Periods 35a and 35b above). Therefore, as previously mentioned, the extra day introduced earlier to complete a 365 day year, ignoring leap years was part of these first and last weeks. Therefore, we must weigh the distribution factors of adjacent periods to start on September 1st, but to get regular 7 days weeks, except for one week of 8 days. For a water year, the first 51 weeks are thus defined, each of 7 days, and at the end of August, the last week of the water year, a week is with a length of 8 days.

Therefore, weekly distribution factors \( \mu_{w'} \) based on numbering for water years \( w' \) are now constructed in much the same way as for the annual water year loads above, by weighting adjacent factors \( \varrho_{w'} \). For instance, if we combine the first period of 3 days \( w = 35b \) and 4 days from the second factor \( \varrho_{36} \) in the water year series, we get an updated and evenly spaced distribution factors \( \mu_1 \). For the first week of the water year:

\[
\mu_1 = \varrho_{35b} + \frac{4}{7} \varrho_{36} \quad (14)
\]

Note that the 3 day period 35b is added completely to the 4/7 of the 7 day long period number 36.

For the 2nd week of the water we get:

\[
\mu_2 = \frac{3}{7} \varrho_{36} + \frac{4}{7} \varrho_{37} \quad (15)
\]

Both periods in (15) are 7 day long. And so forth for other periods of the water year, and finally for the last period of the water year, we have

\[
\mu_{52} = \frac{3}{7} \varrho_{34} + \frac{4}{7} \varrho_{35a} \quad (16)
\]

Therefore in (14), (15) and (16) we can construct the distribution factors for the 52 weeks of the water year, where the last week is 8 days long, but the others have 7 days.

III. NUMERICAL EXAMPLES OF FORECASTING

This section presents a numerical example, based on the EFC forecasts, for annual, weekly and hourly forecasting models. We start by the annual models for a water year.

A. The annual load model

Table I shows the energy forecast 2015-2050 from [3], where the data flow for loads and losses is defined in Figure 2. The Figure defines the major parts of the power system and how the load categories fit to these parts.

As seen in in Table III, described in the next subsection III-B, we have the following values for \( \rho_1 \) and \( \rho_2 = 1 \):

\[
\rho_1 = 0.641 \quad (17)
\]

\[
\rho_2 = 0.359
\]

Therefore, Table II shows the forecast for annual energy in a water year, based on (4) and based on the values for \( \rho_1 \) and \( \rho_2 \) in (17) for general demand only. The EII demand has a flat profile, as shown in I, and the annual values are repeated in Table II, since the values are for water and calendar years.

We will next discuss a numerical example for the weekly distribution factors and load model.
As seen in Table III the weekly periods for are not all of seven days. The Table is derived from Table 5.3 in [2], where \( \sum_{i=1}^{7} \phi_i = 1 \). The EFC has shown these factors for the 52 weeks of each year with an extra day added to week 35. This, of course is needed to complete a 365 day year, assuming no leap years. In Table III we have split up week 35 into a 5 day period (35a) and a 3 day period (35b). Therefore, starting the water year on September 1st will coincide with a start of a weekly period 35b of the calendar year, but only 3 days long. To get a series of 51 weekly periods of 7 days each, followed by one 8 day period, we have again to interpolate between adjacent periods as shown in Table IV.

### Table III

<table>
<thead>
<tr>
<th>Water year number</th>
<th>Water year</th>
<th>General demand with all losses</th>
<th>El Niño demand with all losses</th>
<th>Total demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2015</td>
<td>4,091,14,334</td>
<td>13,824</td>
<td>18,315</td>
</tr>
<tr>
<td>2</td>
<td>2016</td>
<td>4,175,14,334</td>
<td>13,856</td>
<td>18,011</td>
</tr>
<tr>
<td>3</td>
<td>2017</td>
<td>4,258,14,334</td>
<td>13,891</td>
<td>18,142</td>
</tr>
<tr>
<td>4</td>
<td>2018</td>
<td>4,330,14,334</td>
<td>13,927</td>
<td>18,257</td>
</tr>
<tr>
<td>5</td>
<td>2019</td>
<td>4,407,14,334</td>
<td>13,962</td>
<td>18,369</td>
</tr>
<tr>
<td>6</td>
<td>2020</td>
<td>4,532,14,334</td>
<td>13,993</td>
<td>18,425</td>
</tr>
<tr>
<td>7</td>
<td>2021</td>
<td>4,627,14,334</td>
<td>14,035</td>
<td>18,562</td>
</tr>
<tr>
<td>8</td>
<td>2022</td>
<td>4,744,14,334</td>
<td>14,078</td>
<td>18,622</td>
</tr>
<tr>
<td>9</td>
<td>2023</td>
<td>4,869,14,334</td>
<td>14,119</td>
<td>18,700</td>
</tr>
<tr>
<td>10</td>
<td>2024</td>
<td>4,973,14,334</td>
<td>14,158</td>
<td>18,791</td>
</tr>
</tbody>
</table>

### Table IV

<table>
<thead>
<tr>
<th>Period of water year</th>
<th>Water year</th>
<th>Distribution factor ( \phi_{35a} )</th>
<th>Distribution factor ( \phi_{35b} )</th>
<th>Distribution factor ( \phi_{7} )</th>
<th>Distribution factor ( \phi_{1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2015</td>
<td>1.720</td>
<td>1.702</td>
<td>1.730</td>
<td>1.780</td>
</tr>
<tr>
<td>2</td>
<td>2016</td>
<td>1.770</td>
<td>1.752</td>
<td>1.786</td>
<td>1.799</td>
</tr>
<tr>
<td>3</td>
<td>2017</td>
<td>1.830</td>
<td>1.811</td>
<td>1.839</td>
<td>1.850</td>
</tr>
<tr>
<td>4</td>
<td>2018</td>
<td>1.940</td>
<td>1.923</td>
<td>1.953</td>
<td>1.970</td>
</tr>
<tr>
<td>5</td>
<td>2019</td>
<td>2.080</td>
<td>2.058</td>
<td>2.083</td>
<td>2.100</td>
</tr>
<tr>
<td>6</td>
<td>2020</td>
<td>2.170</td>
<td>2.149</td>
<td>2.183</td>
<td>2.200</td>
</tr>
<tr>
<td>7</td>
<td>2021</td>
<td>2.290</td>
<td>2.265</td>
<td>2.300</td>
<td>2.315</td>
</tr>
<tr>
<td>8</td>
<td>2022</td>
<td>2.410</td>
<td>2.385</td>
<td>2.430</td>
<td>2.440</td>
</tr>
<tr>
<td>9</td>
<td>2023</td>
<td>2.540</td>
<td>2.513</td>
<td>2.560</td>
<td>2.570</td>
</tr>
</tbody>
</table>

From the above annual model for water years and expanded to a weekly resolution, as described above, it is straightforward to construct a weekly time series, to be useful, for instance, in expansion planning studies. The weekly load series, based on these numerical data from the EFC, is finally plotted in Figure 3. The Figure shows an increasing load in the period 2015 - 2049 but superimposed by the seasonal fluctuations of the general demand.

Finally we will in the next Subsection make a 2nd expansion to an hourly resolution of the load, based on hourly distribution factors.
C. An hourly load model

Table V shows the hourly distribution factors across hours of different days at three periods in the year. These are, as the weekly factors based on [2], Table 5.4. The EFC assumes 3 different sets of factors, that is Type A in winter, Type B in spring and fall and Type C in summer. and these are all shown in Table V. Also all these distribution factors define between (a) weekday load, (b) Saturday load and (c) Sunday load, as defined by the EFC. All these variations are shown in the columns of Table V for the hours of the day.

<table>
<thead>
<tr>
<th>Table V</th>
<th>HOURLY DISTRIBUTION FACTORS IN A WATER YEAR. BASED ON TABLE 5.4 IN [2], THAT IS ON 2007–2009 DATA.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Type A - Winter</strong></td>
</tr>
<tr>
<td>Hor of the day</td>
<td>Week</td>
</tr>
<tr>
<td>1</td>
<td>0.598</td>
</tr>
<tr>
<td>2</td>
<td>0.481</td>
</tr>
<tr>
<td>3</td>
<td>0.370</td>
</tr>
<tr>
<td>4</td>
<td>0.265</td>
</tr>
<tr>
<td>5</td>
<td>0.167</td>
</tr>
<tr>
<td>6</td>
<td>0.067</td>
</tr>
<tr>
<td>7</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Finally, Figure 4 shows a time plot of the hourly load model as dictated by the distribution factors. In this example the plot stretches from hour 1512, day 63 i.e. week 9 to hour 3192, day 133 that is week 19 of the water year, or approximately from November for 10 weeks to January.

IV. RESULTS AND DISCUSSION

A. Summary of results

In this paper a load forecasting approach has been presented, based on forecasts of the EFC and their weekly and hourly distribution factors. The model has been adapted to water years, suitable for modeling in hydro-based systems in a northern climate. It is designed to be flexible with respect to calendar variation, such as leap years, and 52 week years with an extra day to make a 365 day year, thereby integrating the hourly weekly and annual dynamic properties of the load.

B. Main conclusions

The method presented in this paper should be useful in flexible planning, where interaction is needed between long term and the short term phenomena and constraints. This would be especially useful under the following circumstances:

- Integrating wind load interaction with long term dynamics of reservoirs in a hydro dominated model.
- Modeling the short term phenomena of a spot market and the interactions with the power systems constraints, when short term dynamics is taken into account.
- We note that wind resources and spot markets seem likely to pose new interesting challenges to traditional hydro based system modeling and operations.

ACKNOWLEDGMENT

The author would like to thank the Energy forecasting Committee (EFC) of Orkustofnun (National Energy Authority) for the data and forecasts provided in their reports.

REFERENCES

| 19   | 0.727 | 0.697 | 0.667 | 0.637 | 0.607 | 0.577 | 0.547 | 0.517 | 0.487 | 0.457 | 0.427 | 0.397 |
| 20   | 0.674 | 0.654 | 0.634 | 0.614 | 0.594 | 0.574 | 0.554 | 0.534 | 0.514 | 0.494 | 0.474 | 0.454 |
| 21   | 0.679 | 0.659 | 0.639 | 0.619 | 0.599 | 0.579 | 0.559 | 0.539 | 0.519 | 0.499 | 0.479 | 0.459 |
| 22   | 0.650 | 0.630 | 0.610 | 0.590 | 0.570 | 0.550 | 0.530 | 0.510 | 0.490 | 0.470 | 0.450 | 0.430 |
| 23   | 0.607 | 0.587 | 0.567 | 0.547 | 0.527 | 0.507 | 0.487 | 0.467 | 0.447 | 0.427 | 0.407 | 0.387 |
| 24   | 0.557 | 0.547 | 0.537 | 0.527 | 0.517 | 0.507 | 0.497 | 0.487 | 0.477 | 0.467 | 0.457 | 0.447 |

| Weekly subtotal (%) | 73.653 | 73.276 | 72.909 | 72.542 | 72.175 | 71.808 | 71.441 | 71.074 | 69.707 | 68.340 |
| Weekly total (%) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Figure 4. Hourly load in MW, with losses, for General Demand (GD) and the present Energy Intensive Industry (EII), [2, 3]. Again the EII has a flat profile while the load has a weekly and daily fluctuation. The slight long term decline at right is due to the reduction in load in the beginning of January, as indicated by the distribution factors in Table III. Horizontally, the plot stretches from hour 1512, day 63 i.e. week 9 to hour 3192, day 133 that is week 19 of the water year, or approximately from November for 10 weeks into January.

| Type A - Winter | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |