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ELECTROTEK CONCEPTS

Nemetvolgyi School
Energy Efficiency Demonstration Project Evaluation

Final Report, October 1998

Prepared By

Electrotek Concepts, Inc
Arlington, Virginia U S A

In Association With

Centech Kft
Budapest, Hungary

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And

Nemetvolgyi School
Budapest, Hungary

1 Project Background

The proposed project was selected based on three considerations

1 The site selected (a school with its own heat supply system) is one of the types of facilities identified in the Hungary Project Work Plan as being seriously in need of energy efficiency improvements,
2 The technologies involved in the demonstration project appear to be very cost-effective and are very replicable throughout Hungary, and
3 The District and school involved are financially sound and are highly motivated to reduce energy consumption and related costs

Nemetvolgyi Gymnasium is located in District XII in Budapest, which is located on the Buda side and is one of the two wealthiest districts "Wealthy" is a relative term – meaning that the District is likely to be able to carry out the financial obligations associated with this project and likely to undertake other, similar projects at other schools within the District As evidence of its financial soundness and strong interest in energy efficiency, District XII set up an energy efficiency line of credit with UNICBANK, in order to finance energy efficiency projects at other schools in the district

The amount of energy required by Nemetvolgyi for heating is quite high – about 4,471 GJ per year Annual gas use for heating is also high – 127,745 Nm^3 Substantial opportunities exist for saving heating-related energy Four German-made gas boilers that are at least 10 years old heat the school

Nemetvolgyi consists of two main buildings (A and B) which are linked by a glassed-in passageway Building A, the larger of the two, is 65 years old, and building B is only nine years old Under the current heating control regime, there is a 10° C temperature differential between the two buildings This is because the heating controls regulate the boilers, rather than the pipes Also, the passageway between the buildings is significantly overheated, to about 40° C , typically There is significant infiltration in the passageway, due to many gaps and cracks between the windows Last, the heating system is operated continuously due to the presence of an apartment within the school This results in significant overheating and energy waste of unoccupied schoolrooms during the hours that school is not in session

2 Description of Project

A total of six energy saving measures (designated ECOs) were installed These measures are described briefly below

- ECO #1 - **Fixing the central heating control system**, including controls, valves and sensors The goals of these repairs was to allow for more even heating of the building, and to provide for significant energy savings through nighttime and weekend temperature setback

- ECO #2 - **Installing thermostatic radiator valves (TRVs)** in all classrooms In Building B, only thermostatic heads were required, since new radiator valves were installed just last year
- ECO #3 - **Installing weatherstripping on all windows,** except the nursery area, where it has already been installed
- ECO #4 - **Weatherstripping windows in the passageway**
- ECO #5 - **Installing a thermostat and time switch** on the domestic hot water heat exchanger and pump
- ECO #6 - **Installing a new gas boiler in the apartment,** and calibrating the heating controls accordingly The gas boiler provides considerable energy savings by allowing the central heating system to be shut down during periods when the school is not in session

It should be noted that ECO #6, the gas boiler for the apartment, was installed by District XII, at the district's expense and was therefore, not included in the impact evaluation that is the focus of this report Therefore, the remainder of this report will focus on the characteristics and energy and cost savings from ECO #s 1 through 5 ECO #6 will not be addressed further

General descriptions of the remaining measures (ECOs # 1 through 5) are provided below

Heating Controls

The Nemetvolgyi heating center had heating controls that regulated energy use based on the outside temperature However, these controls did not have the ability to provide for nighttime or weekend temperature setback (when classrooms are unoccupied) The controls installed through this project are fully programmable and allow for temperature-based regulation and reduced nighttime and weekend temperatures It was estimated that the controls would reduce building heating energy use by 15%

TRVs

TRVs reduce energy consumption by automatically shutting off heating energy to the radiator whenever the temperature exceeds the specified set point (20° C) Before the TRVs were installed at Nemetvolgyi, windows were usually opened to vent excess heat, resulting in considerable energy waste It was estimated that 50% of the time the classrooms are occupied, the valves would close off heating energy to the classroom, reducing energy consumption by an additional 10% Also, because the TRVs provided for more even heating of the building, additional savings accrue Previously, the building heating system was operated to provide sufficient heat for the coldest room in the building As a result, the building was overheated to an average temperature of 22 5° C With the TRVs and weatherstripping (see below), the building could be heated to a more moderate temperature of 20° C , resulting in additional energy savings

Weatherstripping

Weatherstripping on windows located immediately above the radiators was proposed to reduce infiltration and resulting heat losses from the building   At Nemetvolgyi, additional weatherstripping was installed in two locations (1) on windows located immediately above the radiators where TRVs were also installed, and, (2) in the passageway connecting buildings A & B

With respect to the first location, effective weatherstripping was especially important in conjunction with TRVs, since the weatherstripping helps to keep the room temperature at or above the TRV set point   Nemetvolgyi's existing weatherstripping was deteriorated and needed to be replaced   In addition, some of the wooden window frames had sagged and needed to be planed, so that an effective weatherstripping barrier could be installed

In the passageway (the second location), there were significant problems with infiltration, overheating and energy waste   This passageway is almost entirely composed of single-paned glass windows, and the windows and frames were ineffective in keeping out cold air To effectively address these problems, two different types of weatherization materials were installed   The first type was an energy-efficient window film that was installed on the inside surface of all windows in the passageway   The second type was conventional weatherstripping, to seal off cracks and gaps in the frames surrounding these windows

3 INSTALLATION OF PROPOSED MEASURES

Originally, it was planned that the proposed energy savings measures would be installed before the start of the 1997-98 heating season (ideally, before the start of the school year)   However, the project design, approval process, and procurement of equipment all took longer than expected   As a result, the equipment installation took place in November and December of 1997   Despite this delayed schedule, it was still quite early in the heating season and there was sufficient time left to collect monitoring data and do the project impact evaluation

4 QUANTITATIVE EVALUATION OF ENERGY SAVINGS AND PROJECT PAYBACK

Methodology Used to Compute Annual Energy Savings

To compute the energy savings for this project, both whole-building metered data and direct observations (using data collected through temperature data loggers) were used The following describes the step-by-step method used to estimate the energy savings for the various installed measures was as follows

Step 1 Monthly Data on Total Building Heating Energy Use Was Collected Whole-building heat meter data was collected for the months of January 1998 through April 1998 Note – because the installation of the energy-savings measures was not completed until Christmas break, it was not possible to incorporate observations from the early part of the heating season into the impact evaluation

Step 2 Monthly Heat Metered Data for the Same Months During the Preceding Three Years Was Collected and Averaged The 3-year average is meant to represent a typical base year In previous project evaluations, CENTECH has found that the 3-year average eliminates much of the year-to-year variance due to fluctuations in facility use, occupancy levels, etc It, therefore, is a more accurate benchmark of base period usage than is metered data from the previous calendar year

Step 3 Heating Consumption Data for the Base Period and for the 1998 Heating Season Was Weather Normalized Because the weather during the 1998 heating season was unusually warm, this step was very important Heating degree-day information for a typical year and for 1998 was collected The degree day information that was collected and used in these calculations is shown in the following table

	Degree Days in	
Month	**Typical Year**	**1998**
January	617	529
February	530	398
March	461	470
April	193	181
TOTAL	**1,802**	**1,578**

A degree-day correction factor was developed from this data and subsequently applied to the whole building metered data to correct for the effects of the unusually warm winter After adjusting for the effects of weather, the energy savings estimates for the total project declined from 42% to 33% All subsequent calculations were based on the weather-normalized energy savings figures

The following table provides the monthly estimates of energy savings for the entire project (i e , all installed measures) In subsequent steps, these estimates are further broken down by measure

Month	GJs in Base Year	GJs in 1998 Heating Season	Savings In GJs	Savings As %
January	819	885	-65	-8%
February	872	610	262	30%
March	760	206	554	73%
April	748	141	307	41%
Total	**3,200**	**2,141**	**1,059**	**33%**

NOTE – Energy use in January 1998 was higher that in the base year, in part, because the heating controls were not working properly due to problems with excess air These problems were subsequently corrected and the controls did work as intended during the remaining months of the monitoring period (February through April 1998)

Step 4 Total Energy Savings was Disaggregated by Measure For all measures except for the weatherstripping, engineering calculations were used to compute energy savings for each type of measure The engineering savings equations were modified to incorporate actual heating control regimes, indoor temperatures, setback times, etc Interactive effects between measures were incorporated by reducing the heating baseline step-wise for each measure installed Measures were evaluated in decreasing order of cost-effectiveness/payback Thus, heating controls were considered first, TRVs next, and weatherstripping last

a) For heating controls, energy savings was arrived at using the following equation

Energy Savings = (Annual Heating Requirement X % Controlled Floor Space) X (Number of Hours of Setback X # Degrees Reduced X 6% Savings per Degree Reduced during Setback)

b) For TRVs, the energy savings algorithm was as follows

Energy Savings = (Annual Heating Requirement * X % of Floor Space for Classrooms) X % of time classrooms are not occupied X % of time when TRVs Close off Heating**

* Reduced by the energy saved from the heating controls
** Based on actual experience

c) For weatherstripping, the residual energy savings that was not attributable to either the heating controls or TRVs was assumed to be due to the weatherstripping The resulting energy savings level, as a percentage of total energy consumption, is well within the range of savings claimed by weatherstripping manufacturers

The energy savings and simple payback for each of the installed measures is shown in the table below

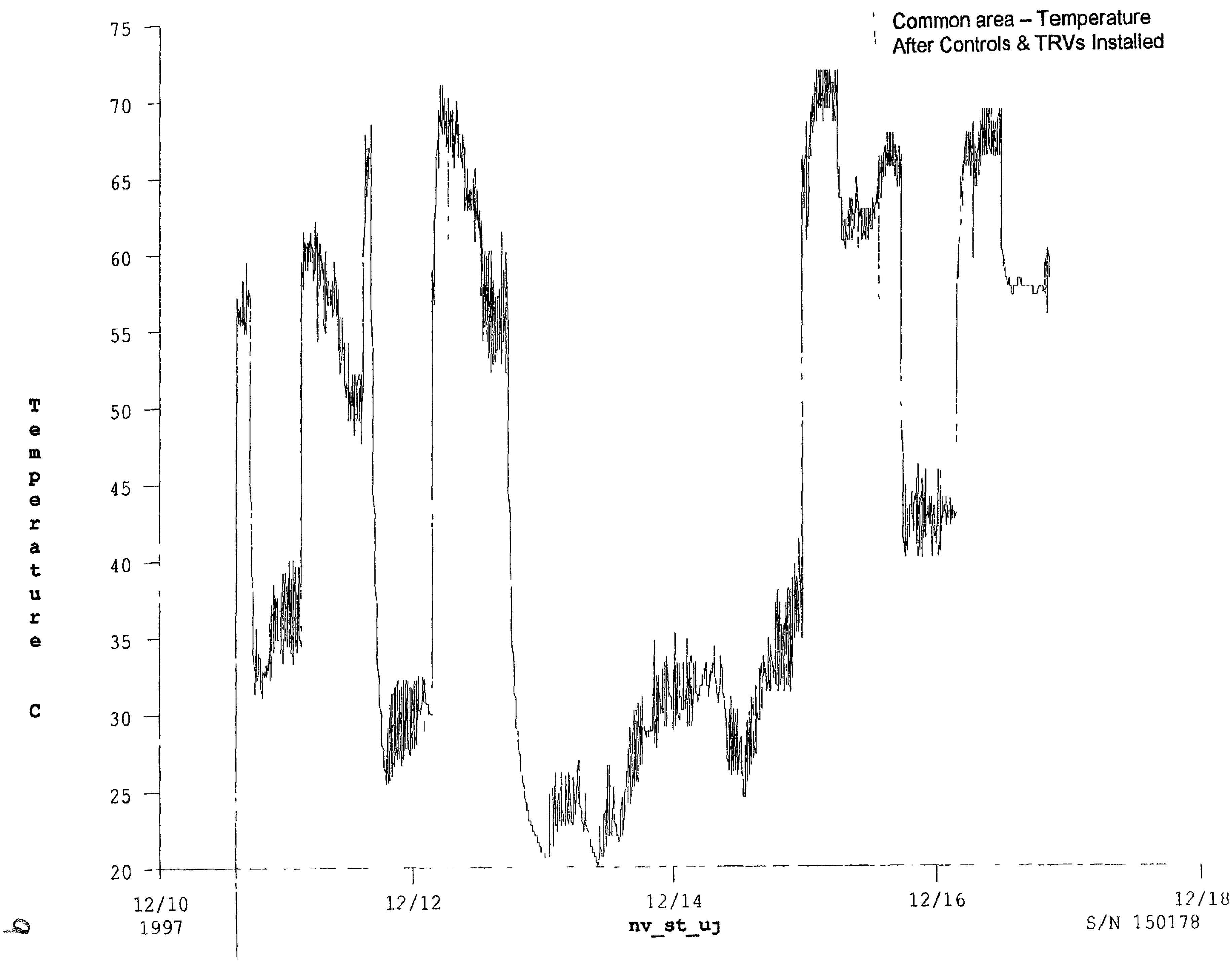
No	Measure	Energy Savings %	Energy Savings GJ/yr ***	Energy Bill Savings KFt /yr	Measure Cost in KFt	Simple Payback (years)
1	Heating Controls	18 0%	914	742	833	1 1
2	TRVs	8 6%	434	352	999	2 8
3	Weatherstripping (above TRVs)	4 5%	226	183	750	4 1
4	Weatherstripping in Passageway	1 4%	72	54	160	3 0
5	Domestic Hot Water Control	0 5%	24	18	33	1 8
6	**Total**	**33 0%**	**1,361**	**1,017**	**2,775**	**2 7**

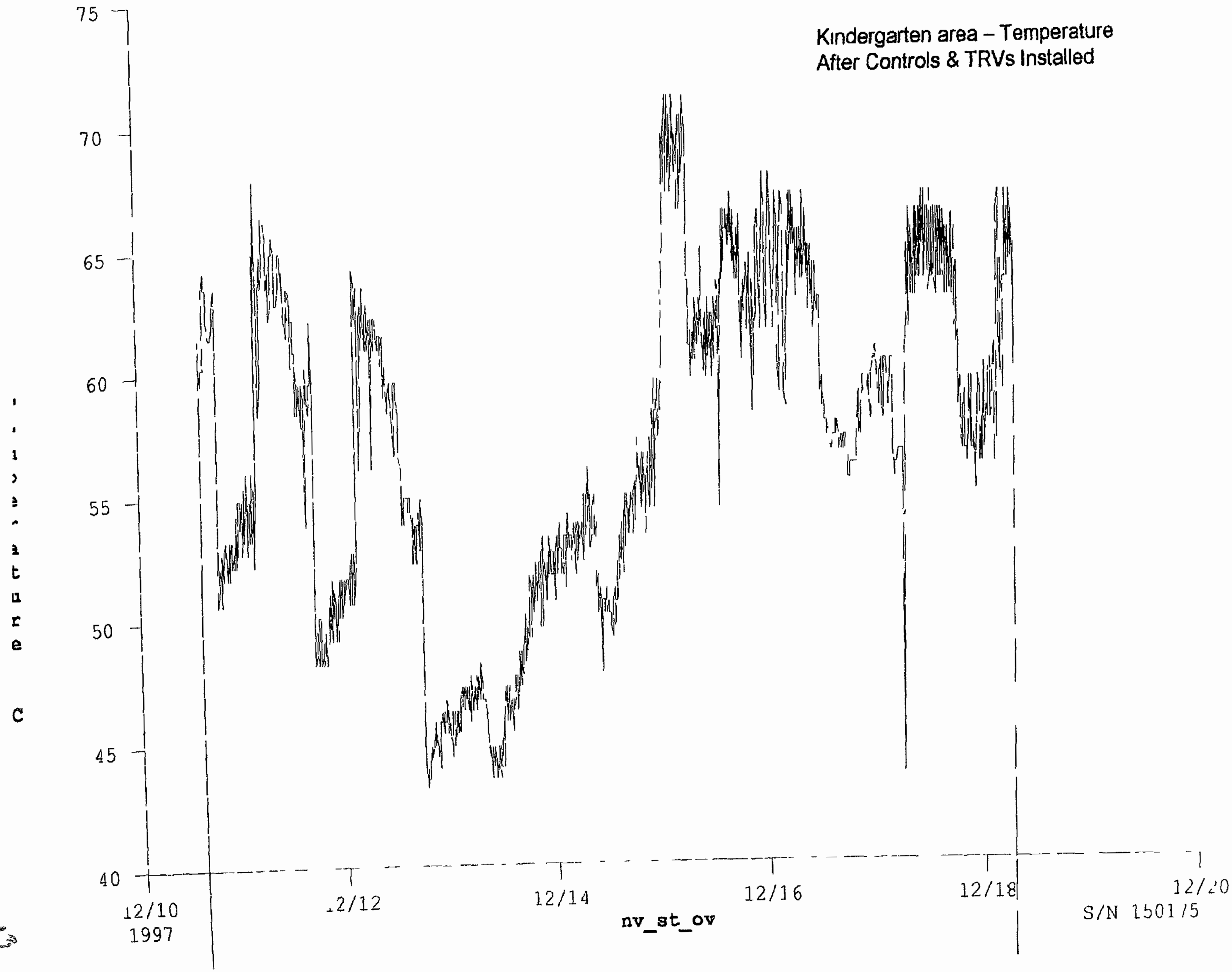
*** Over the entire heating season Please note that the monitoring period was considerably shorter and therefore, the energy savings shown in the preceding table were considerably lower However, on a percentage basis, they are the same

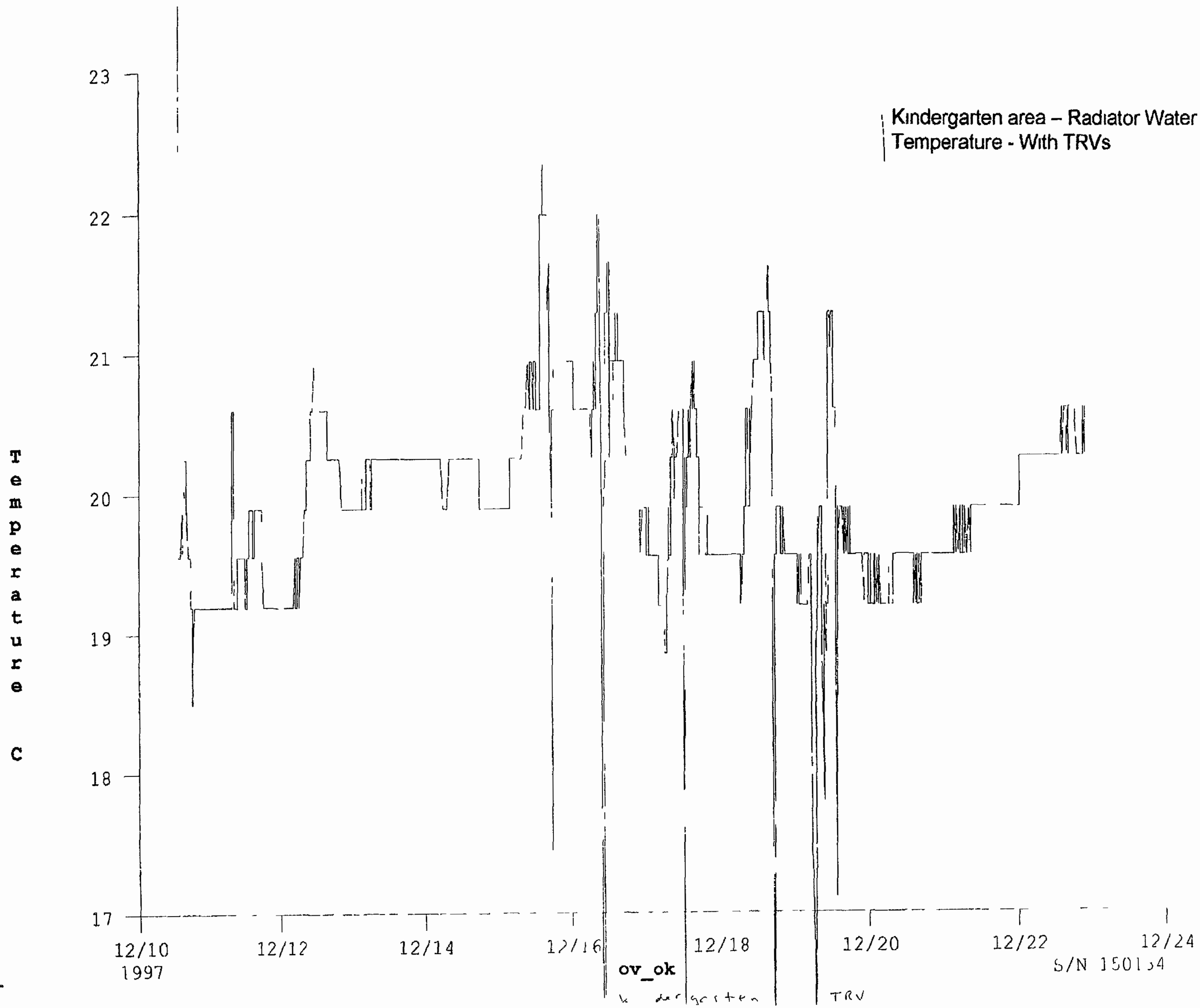
As the table shows, this project was very cost-effective, based on simple payback For all measures, the payback was 4 1 years or less, with the payback on heating controls the shortest at only 1 1 years Paybacks for the remaining heating-related measures (ECO #s 2, 3 and 4) were somewhat longer, in part because the energy baseline used to evaluate these measures was reduced to account for the savings from the heating controls Nonetheless, all measures were found to be cost-effective

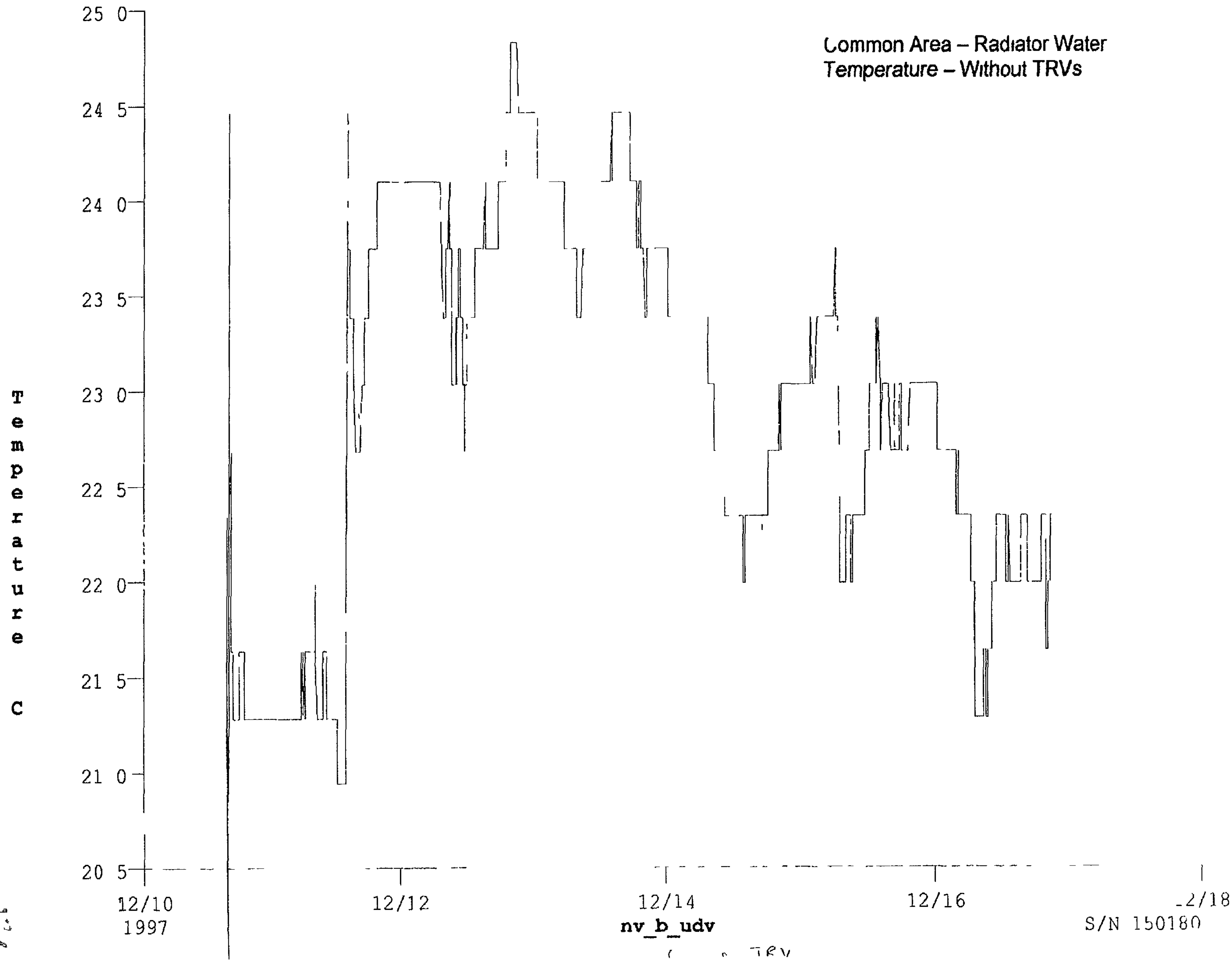
Appendix A provides some plots of the temperature monitoring that was done after the ECOs were installed and working properly In particular, the plots demonstrate the dramatic impact of the control regimes for the heating controls and TRVs

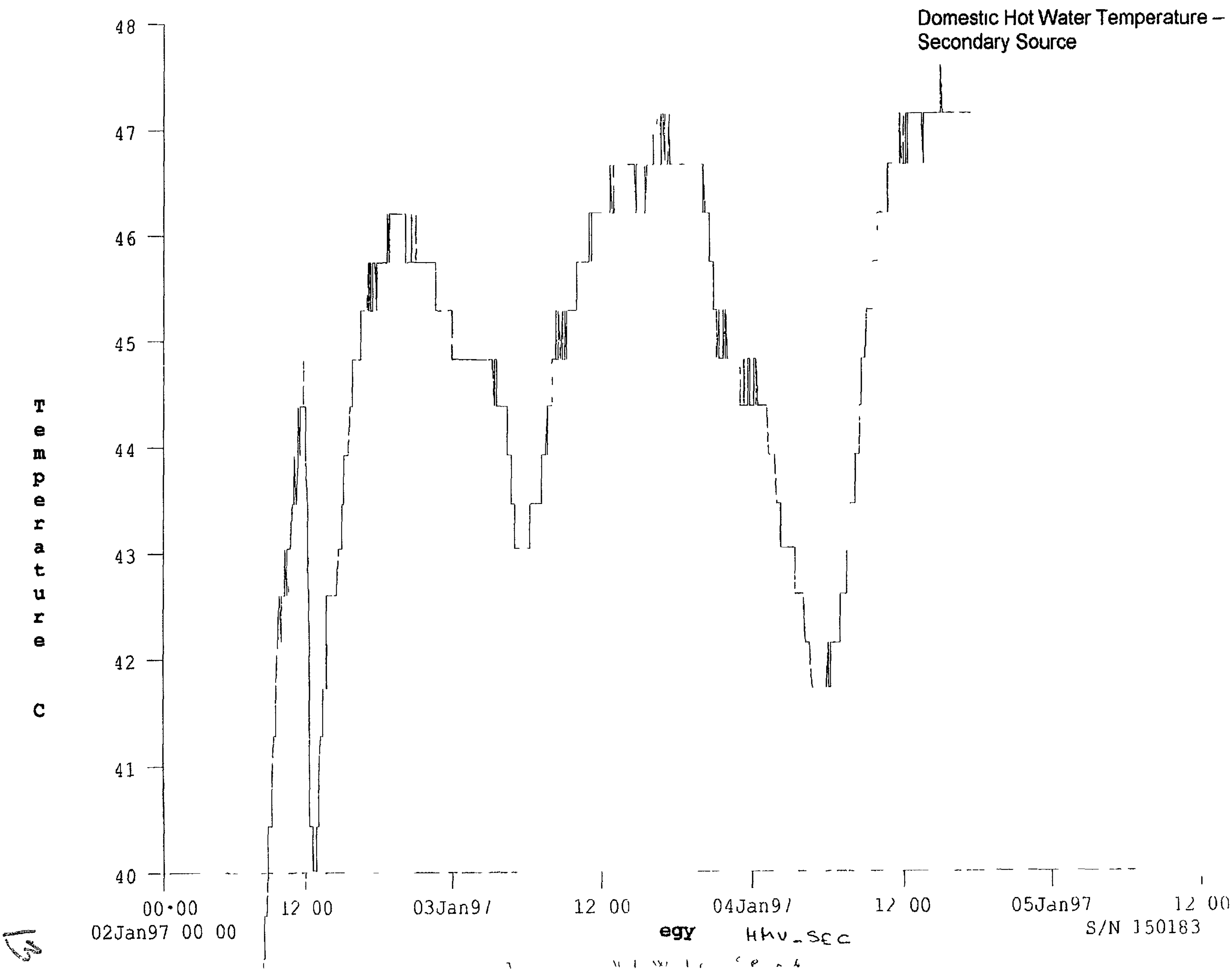
APPENDIX A – RESULTS OF TEMPERATURE MONITORING

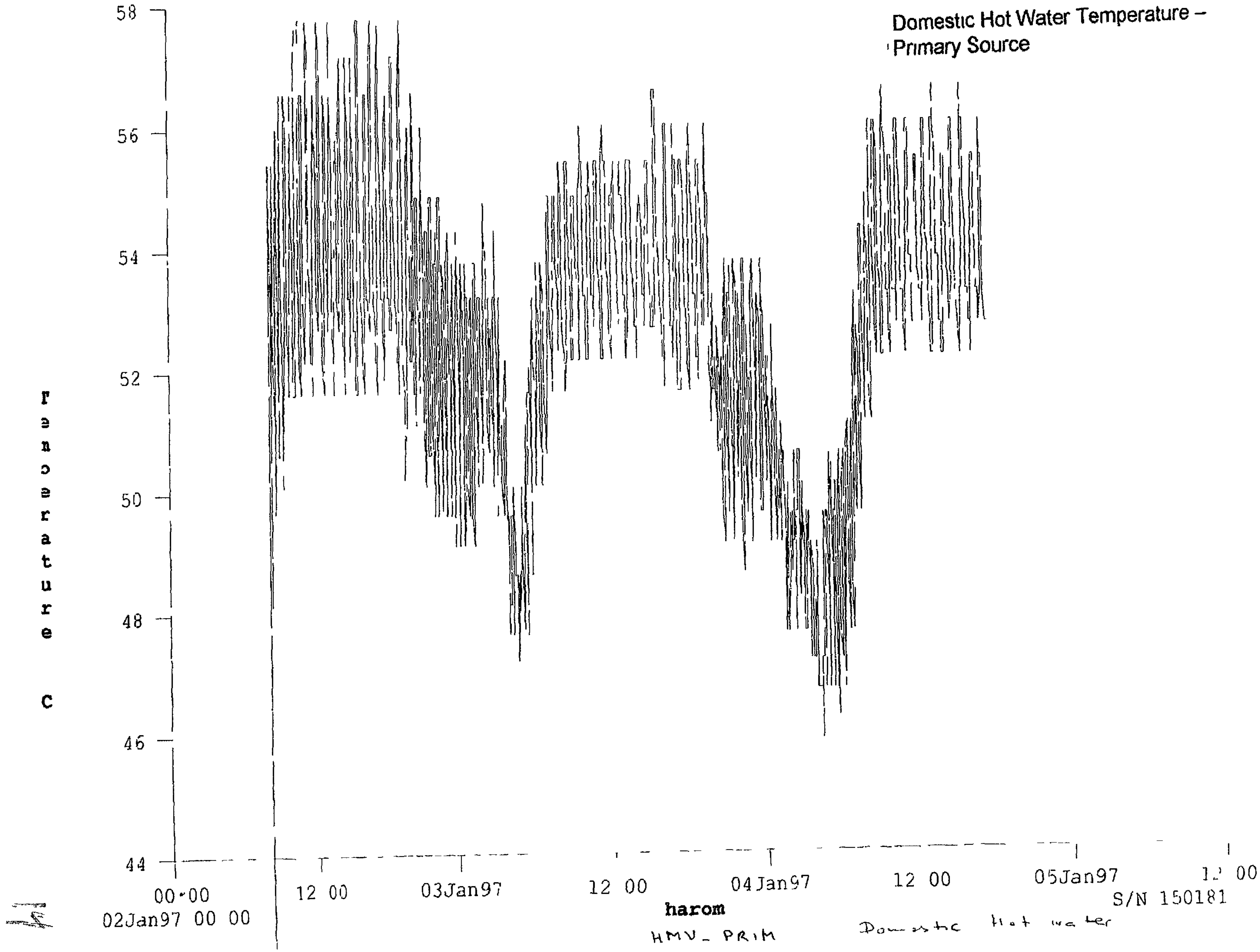

Common area – Temperature
After Controls & TRVs Installed
Temperature C
75
70
65
60
55
50
45
40
35
30
25
20
12/10
1997
12/12
12/14
12/16
12/18
nv_st_uj
S/N 150178


Kindergarten area – Temperature
After Controls & TRVs Installed
75
70
65
60
55
50
45
40
Temperature C
12/10
1997
12/12
12/14
12/16
12/18
12/20
nv_st_ov
S/N 150175


Kindergarten area – Radiator Water Temperature - With TRVs
Temperature C
23
22
21
20
19
18
17
12/10 1997
12/12
12/14
12/16
12/18
12/20
12/22
12/24
ov_ok


Common Area – Radiator Water
Temperature – Without TRVs
Temperature C
25 0
24 5
24 0
23 5
23 0
22 5
22 0
21 5
21 0
20 5
12/10
1997
12/12
12/14
12/16
12/18
nv_b_udv
S/N 150180


Domestic Hot Water Temperature – Secondary Source
48
47
46
45
44
43
42
41
40
Temperature C
00:00
02Jan97 00 00
12 00
03Jan97
12 00
04Jan97
12 00
05Jan97
12 00
egy
HHv_SEC
S/N 150183


Domestic Hot Water Temperature –
Primary Source
Temperature C
58
56
54
52
50
48
46
44
00·00
02Jan97 00 00
12 00
03Jan97
12 00
04Jan97
12 00
05Jan97
12 00
harom
S/N 150181
HMV_PRIM
Domestic Hot water