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IMPLEMENTATION OF ELECTRODE BOILERS FOR FREQUENCY CONTROL OF UTILITY GRIDS

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HUIBERT ANTONIE VERRA
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IMPLEMENTATION OF ELECTRODE BOILERS FOR FREQUENCY CONTROL
OF UTILITY GRIDS

A THESIS APPROVED FOR THE
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

BY

[redacted]

Dedication

I dedicate this thesis to my wife and my parents. Jeannie, your love, support and patience made it possible for me to pursue this degree.

Mom, dad, thank you for your continuous moral support and for believing in me.

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Foremost, I would like to thank my advisor Dr. John Dyer for his tireless efforts and support during my research and writing of this thesis. I could not have wished for a better mentor.

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Abstract

This thesis successfully demonstrates an algorithm for improving the power control of a high-voltage electrode boiler being utilized for load-frequency control, by actively adjusting the slopes of XY-curves used for boiler water level control set-point and outputs as a function of boiler temperature.

The increase in transient energy co-generation, such as wind-power, places greater demands on an electrical grid for maintaining load-frequency control. A common method for load-frequency control used in Europe is decentralized co-generation plants with high-voltage electrode boilers. These provide a secondary benefit of hot water district consumer use.

Current high-voltage electrode boilers used for load-frequency control do not account for water temperature when determining conductivity and water-level set-points. Set-point curves are determined at the time of commissioning and then set. This thesis develops and tests an algorithm that accounts for boiler water temperature and dynamically adjusts the XY-curves that define the system behavior. The tested algorithm showed a clear improvement in maintaining load-frequency control, reducing the mean power error to $0 \pm 0.5\%$.

Chapter 1: Introduction

This thesis successfully demonstrates an algorithm for adjusting level set-points and controller outputs for a high-voltage electrode boiler. These boilers are typically used as an electrical load in load-frequency control of the electrical distribution grid. The current control software does not include actual boiler temperature in the control algorithms causing an inaccuracy and deviation in the consumed power. The proposed algorithm improves the accuracy of the controller, consequently enhancing efficiency and lowering operational costs. The proposed algorithm is vital because growing renewable energy generation, specifically wind power, causes increased frequency deviations that cannot be adequately handled by traditional methods.

Wind energy is experiencing the most substantial growth of all sources of power generation. A status report from the global Renewable Energy Council (REN) [1] shows that wind power has had an annual growth rate of more than 20%. In many areas wind power is supplying as much as 20% of the total energy demand [2]. By the end of the year 2012 the total installed wind power capacity worldwide was more than 282 GW, 21% of this was generated in the United States (60 GW) [3]. Wind turbines, in particular variable-speed wind turbines, are very different from conventional thermal power generation, because they are not synchronous to the electrical frequency of the power distribution grid. Therefore, changes in load demand cannot adequately be opposed by inertia of the generator.

Mains frequency or grid frequency are synonyms for the frequency of electrical generation. The nominal frequency is 50 Hz for most of the world, but 60 Hz in the United States and the Northern parts of South America.

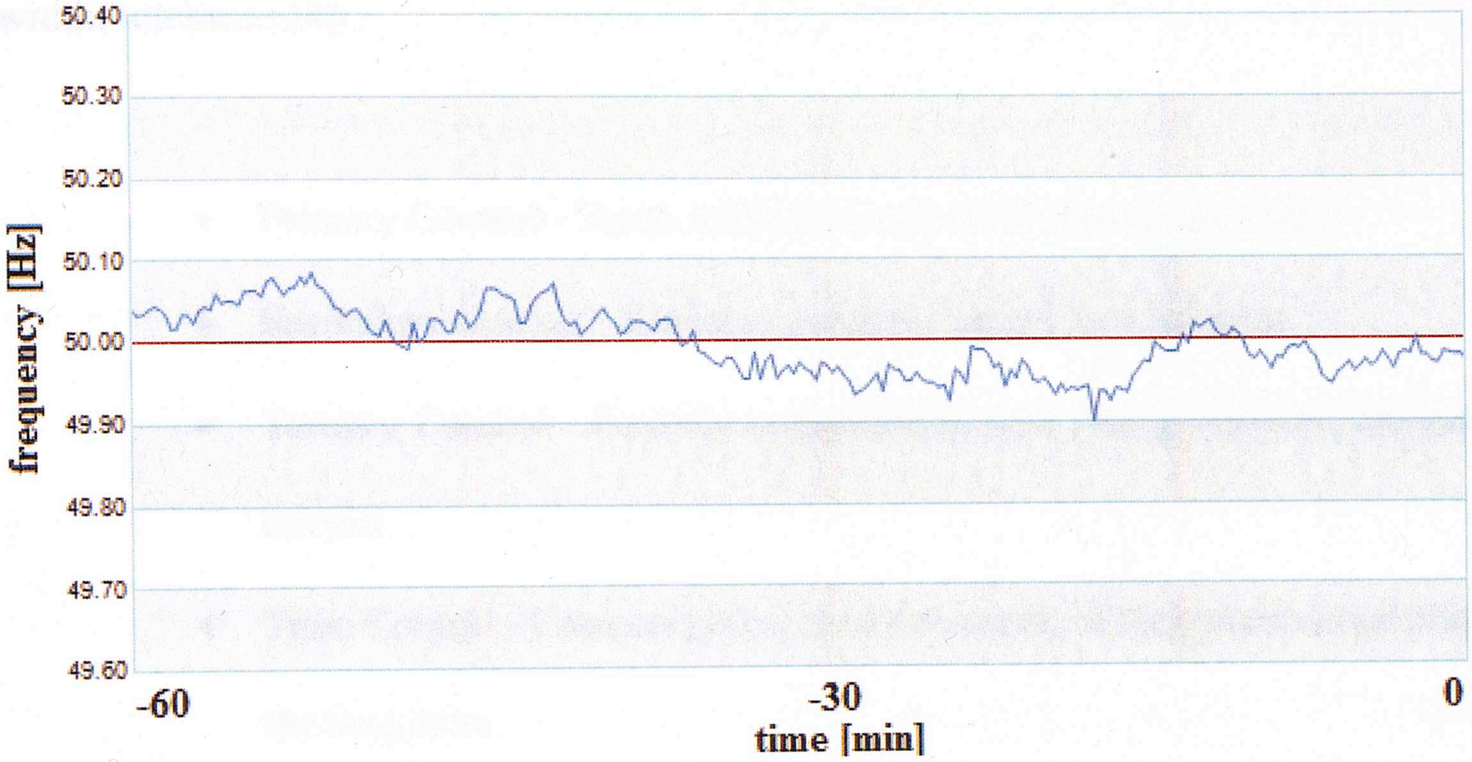

Figure 1 Typical Frequency Data over Period of One Hour

Figure 1 shows a graph depicting the system frequency during an hour with a 15 second resolution. The frequency is always changing and is determined by the balance between demand and supply. If demand is greater than generation the frequency will fall. Slight deviations of up to 100 mHz from the nominal frequency are very common, but it is critical to avoid deviations that exceed 200 mHz to secure the synchronous areas.

One of the main objectives of power system control is to actively counter frequency deviations in the distribution grid. Increasing the mechanical input to a synchronous generator will not directly increase the frequency, but will increase the power supplied by this generator. To achieve a balanced load versus generation ratio, automatic load-frequency control is used. Load-frequency control consists of three phases, primary, secondary and tertiary. Some companies add a fourth phase called time control. The relation between the phases of load-frequency control is shown in Figure 2. The four types of mains frequency control implemented to help ensure deviations remain within tolerance [4]:

- Primary Control - Starts within seconds of deviation detection.
- Secondary Control - Replaces primary control over minutes.
- Tertiary Control - Partially complements and finally replaces secondary control.
- Time Control - Corrects global time deviations of the synchronous time in the long term.

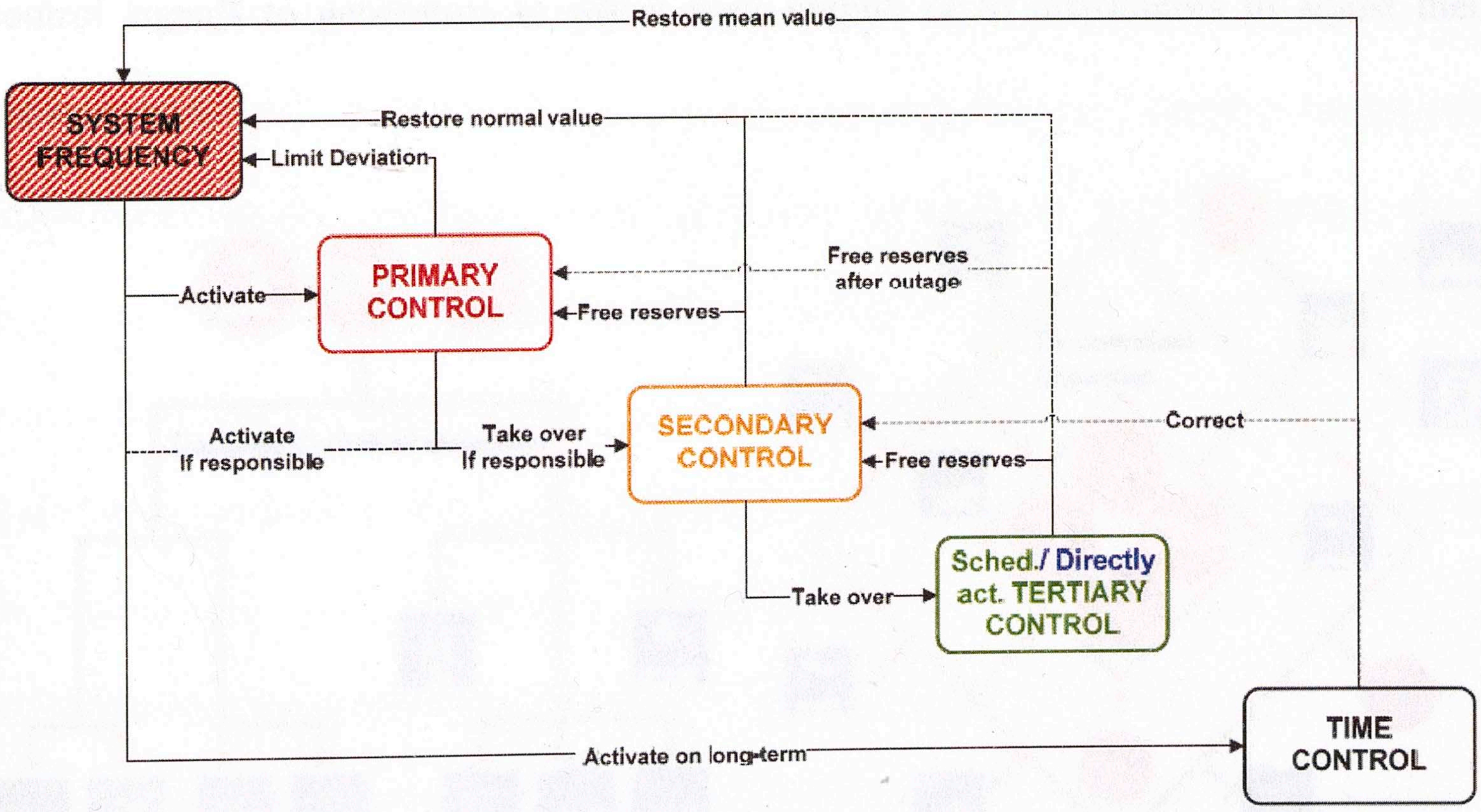

Figure 2 Control Scheme and Actions Starting with the System Frequency (Courtesy of UCTE OH)

The fundamental control problem with any power system is to match the power generation to the actual absorbed power (including net losses) [5]. Load frequency control is becoming more significant due to the increasing number and complexity of interconnected power systems. Smaller systems that are not interconnected with many loads and generators will not maintain frequency with the same degree of accuracy. In the past all transmission and generation facilities were owned by a single utility that would issue real power control signals to all of the generators within its network. World-wide deregulation has decentralized and deregulated the structure of real power control. In Europe generation, transport and distribution are handled by different commercial entities. A solution to maintaining load-frequency control in a single grid operated by multiple suppliers, commonly used in Europe by the transport company, the company that ties up all generators and distributors, is accomplished by control algorithms issuing control signals to generators to adjust their output, or to distributors to adjust their consumption.

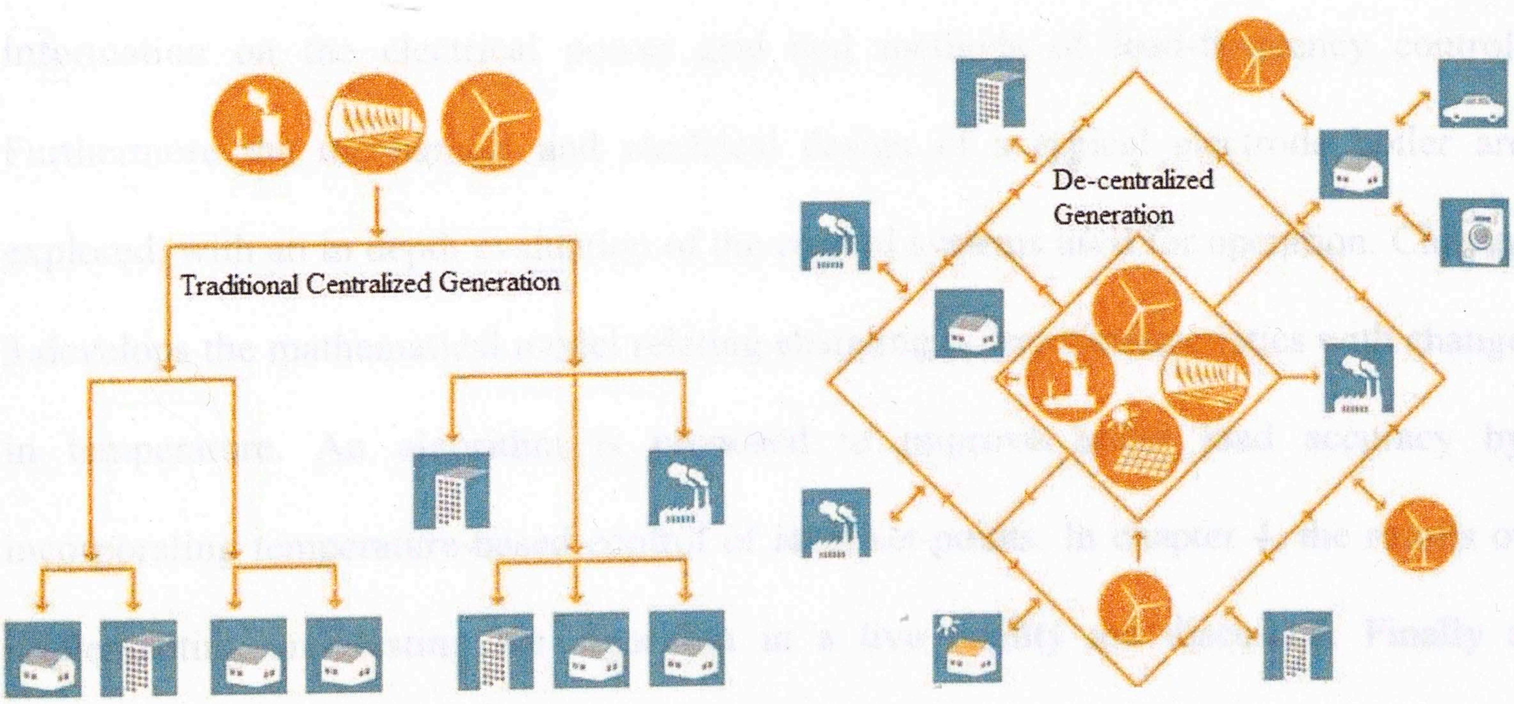

Figure 3 Traditional Centralized and Decentralized Generation

In Denmark, many companies have emerged that fill the role of both producer and consumer in the distribution net. Smaller co-generators and fast acting loads are used to actively perform load-frequency control close to the consumer. The difference in configuration is shown Figure 3.

Power production is achieved by these co-generators in the form of gas-engines and wind-turbines, while power consumption can occur by means of high-voltage boilers. The use of large loads for load-frequency control is a rather new concept in Denmark and even though the overall performance of this method is good, there are some volatility and precision issues. These issues are closely related to the fact that the power consumption changes as the temperature of the boiler changes.

This thesis evaluates an algorithm to actively adjust level set-points and controller outputs as a function of actual boiler temperature, in high-voltage electrode boilers that are used to perform load-frequency control of the grid. Chapter 2 presents background information on the electrical power grid and methods of load-frequency control. Furthermore the mechanical and electrical design of a typical electrode boiler are explored, with an in depth evaluation of the control systems used for operation. Chapter 3 develops the mathematical model relating changing power characteristics with change in temperature. An algorithm is proposed to improve boiler load accuracy by incorporating temperature-based control of level set-points. In chapter 4, the results of implementing and testing the algorithm in a live facility are discussed. Finally a conclusion is made and future research goals are proposed.

Chapter 2: Background

Electrical power consumption has been on a steady rise since Benjamin Franklin successfully researched the phenomena and sold his inventions in the 18^{th} century. However, not until the late 19^{th} century was real progress made thanks to research and inventions from numerous contributors [6]. Historically all energy was produced near the load requiring it; the first centralized element in modern energy industry was the production of gas. By the end of the 19^{th} century, serious progress was being made on the expansion of the electrical power grid. Most of the early electric power used Direct Current (DC) and Edison devised the first power transmission system. Edison's DC system generated and distributed electric power at the same voltage as was used by the consumers' loads. This meant that the current in transmissions was rather large and conductors had to be large, further limiting the transmission distance. This forced the power companies to run different lines for different customer classes. Due to the large number of lines needed and inefficiencies of the transmission due to high current, the need to develop a distributed generation system arose [7]. In the modern Alternating Current (AC) system, distribution power can be transported more efficiently over larger distances. Transformers at both ends of the transmission are used to respectively raise and decrease the voltage levels. Generated power at generating stations is between 1 and 30 kV, while voltage levels commonly used for transmission of power range from 138 to 765 kV. Finally, the voltage is stepped down to accommodate consumers ranging from

120 V to 13 kV. Larger consumers are often directly supplied from the transportation net by means of dedicated transformers. See Figure 4 below.

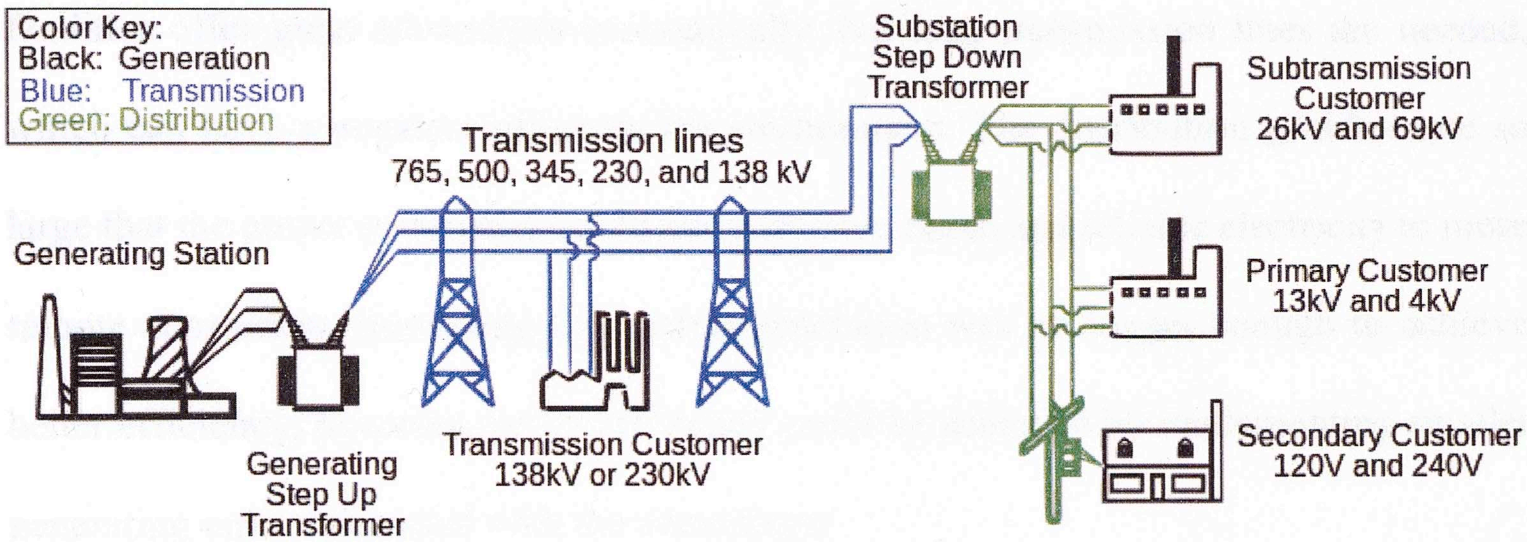

Figure 4 Simplified Typical Electricity Grid

The increased voltage level and consequently decreased current level inherent in AC power systems, greatly reduces power loss in the transmission lines, which makes it possible to transport power over longer distances. With the realization of long distance power transportation, power companies interconnected local stations for the sake of load balancing and the improvement of the load factor. This is possible because larger grids offer the possibility of sharing power generation through different regions and diversification of loads. The load factor is defined by dividing the average load with the maximum load over a given time period. A high load factor indicates a constant power usage, while a low load factor shows an occasional high load demand. Interconnection of individual grids will balance the load better, resulting in a higher load factor. The electrification of the world further promoted this interconnection in the early 20th century and in the 1920's United States utilities joined together.

2.1 Decentralized Electrical Power Generation

Historically, the generation of electrical energy was done in large centralized facilities often by means of natural gas, coal and nuclear or hydropower plants. Large facilities offer great advantages economically, but long transmission lines are needed, which can have a negative effect on the environment. The distribution grid became so large that the power companies could not guarantee cheap and reliable electricity to more remote consumers. Increasing the central generation was no longer enough to achieve better efficiency; however, better efficiency could be achieved by implementing smaller generating units collocated with the consumers.

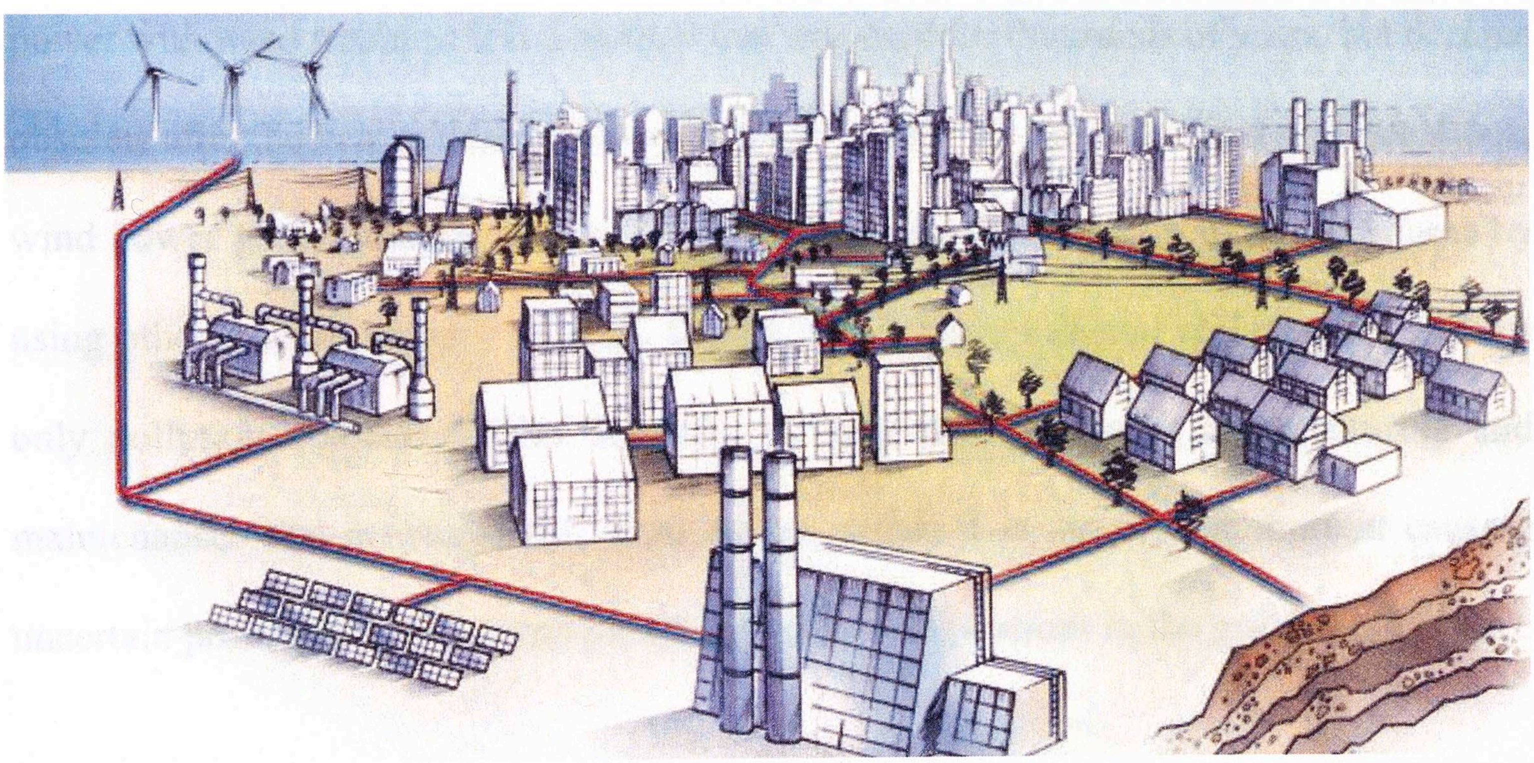

Figure 5 Typical District Heating Grid Lay-Out

A much-used decentralized generation method is cogeneration, which is the use of an engine to generate both electricity and heat used for heating applications. A typical lay-out of a co-generation grid is shown in Figure 5.The efficiency for generating electricity by means of a gas engine is often not more than 30 to 40%, but an increase to 90% or higher is possible by means of heat recovery from the flue gasses emitted by the generator. Waste heat recovery is achieved by inserting a coil in the smoke stack through which water is circulated. The hot flue gas heats up the water that then can be used for heating purposes. Heat consumers are often industry, hospitals, green houses or district heating facilities. In a country like Denmark, 62% of households are connected to district heating [8], where many decentralized facilities supply both thermal energy and electricity. Decentralized cogeneration is considered to have vast environmental and economic advantages [9].

Another method of decentralized generation is to use wind power to generate power with wind turbines; it is a method that was used for thousands of years, but became obsolete after the industrial revolution. In the early 1970's, during the first oil price shock, wind power generation made a comeback as a reliable and consistent power source by using other sources as back up [10]. Wind turbines have minimal maintenance and the only pollution associated with this kind of generation is during manufacturing and maintenance. The problem with wind power is that it is usually intermittent causing uncertain power availability and possible frequency deviations in the grid [11].

Not only the number of installations is rapidly increasing, but also the capacity per installation has increased immensely [12]. In the 1980's 300 kW turbines were state of the art; by the time of writing in 2014 an 8 MW turbine has been deployed by the Danish company Vestas [13]. The increase in number of units and capacity per unit, has significantly affected the variation in load-frequency.

2.2 Load Frequency Control

The quickly increasing number of wind turbines in the grid will result in a decreasing number of conventional power plants requiring new methods of load-frequency control, the controlling of real power output of generating units in response to changes in system frequency within specified limits. To maintain a stable grid frequency is important for numerous time dependent devices such as:

- Tariff meters of electrical energy.
- Power plant control energy.
- Power quality devices.
- Synchronous motors.

Load frequency control is part of the automatic generation control system and is critical in the operation of power systems and is organized in three or four levels [14] [15]. The four levels consist of primary, secondary and tertiary control, and optionally time control.

2.2.1 Primary Control

The controllers of the generating units perform the primary control. The first phase relies on the release and absorption of kinetic energy by the rotor of the synchronous generators, resulting in a change of frequency. Consequently, active controllers change the input to the generators. Since the generators inside wind turbines are much smaller than conventional synchronous generators, the inertia contribution of these turbines is much smaller. Transients of primary control are usually in the scale of seconds. If the deviation from the nominal frequency exceeds ±20 mHz in the Continental European model, primary control is activated. This number is derived from the sum of the allowable measurement error of 10 mHz and a 10 mHz dead zone of the controller. The primary control is proportionally activated from 0% to 100% when the deviation is ±20 mHz to ±200 mHz. While long-term (30 second) deviations of maximum ±180 mHz are permissible, short-term (seconds) deviations of up to ±200 mHz are allowed. Maximum activation of the generator occurs in the event of a frequency deviation of 200 mHz or more. Maximum activation has to be reached within 30 seconds of the frequency deviation. It must remain available for at least 30 minutes. Primary control is not able to return frequency to normal levels, it can only stabilize it. The other control components are used to restore frequency levels [16].

2.2.2 Secondary Control

The next phase, secondary load frequency control, consists changing the set-point of the engine feeding the generator, causing the frequency to be brought back to its nominal value. Secondary load-frequency control is used to restore frequency to its scheduled value, following a disturbance. The time associated with this type of control ranges from one to ten minutes.

2.2.3 Tertiary Control

The third phase is called tertiary control, also referred to as "minutes reserve." It is activated when the deviation in the control area lasts for longer extents of time (10 to

30 minutes) and is used to relieve secondary control, so that it can be implemented again. Secondary control should be available at all times to ensure correct load-frequency control. Tertiary control consists of actions taken to get additional resources in place to handle current and future incidents.

2.2.4 Time Control

The last phase is time control. Because load-frequency control and balancing are not perfect, there will always be small deviations in net frequency. Time control is used to maintain the long term average frequency at its scheduled value (50/60 Hz). If average frequency drifts, it creates a time error in the net. If for example the average frequency over a day has been running high, a clock using the frequency will gain several seconds. All balancing authorities will decrease the scheduled frequency by a small margin until the average frequency is restored to normal. To determine the actual frequency the Coordinated Universal Time (UTC) is used. The electrical time of the synchronous area is determined by the integration of the frequency / voltage time period.

2.3 Regulation Reserves

Alternative energy sources are in the spotlight and are experiencing an immense growth rate. The integration of these renewable energy sources with the existing load-frequency control is very challenging. The energy sources are mostly connected to the grid through electronic power converters, and no inertial response can be provided as feedback for load frequency control [17]. Instead of using a generating capacity for primary load-frequency control, a load can be used. This load has to be able to change power consumption relatively fast from low load to full load in less than 30 seconds, and vice versa. There are three distinct areas of use: 1) Primary or secondary control to increase the generation capacity or decrease power demand (regulate up reserves); 2) decrease the generation capacity or increase power demand (regulate down reserves); or 3) a combination to facilitate both (combined control). These types of load-frequency control can be very attractive when the prices for electricity are low, because to use a high-voltage electrode boiler a certain power capacity has to be purchased. When prices are low, the boiler can be used to produce thermal energy at a very low cost. When prices are high, electrical power generated by means of co-generation can be sold to the operator and the thermal energy that is a by-product of this form of generation can be sold to the consumer. In Northern Europe, an electricity exchange has come to life. This exchange gives potential consumers and contributors the opportunity to buy or sell electrical capacity in certain periods. Northern Europe is largely dependent on hydro and wind power. Periods of little precipitation or wind can cause a deficiency in power generation. When there is still power demand, prices increase and it becomes very lucrative to sell capacity. However, when demand is very low or there is an abundance in hydro or wind power, it can be very efficient to buy capacity. Many district heating facilities in Northern Europe cogenerate electricity and thermal energy. When power demand is low, but there is a demand for heat, heat generation is usually performed by gas-fired boilers. However, when the cost to generate heat-using electricity is lower or even negative as highlighted in Figure 6, this becomes a very lucrative possibility.

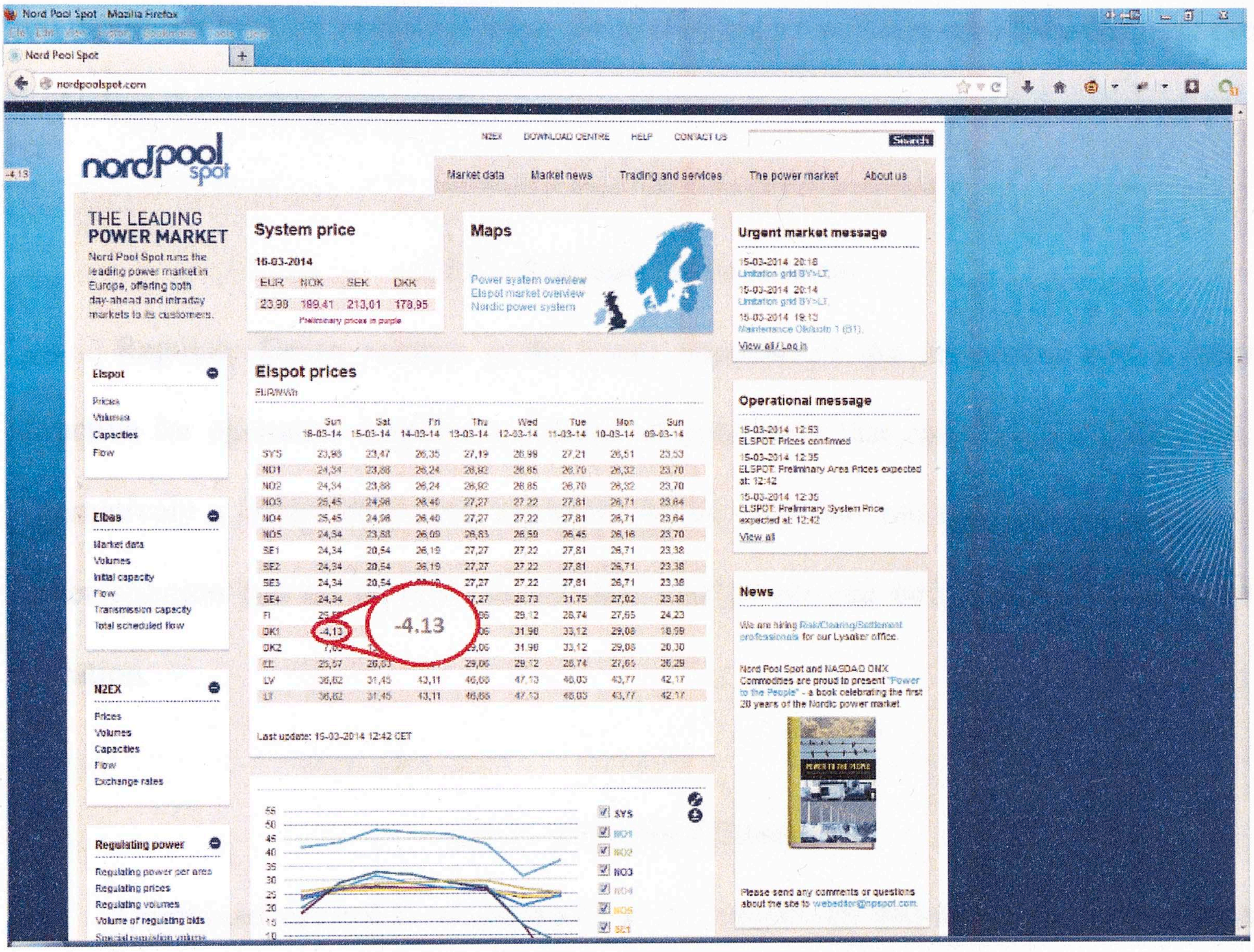

Figure 6 Nordpoolspot Power Exchange

2.3.1 Regulate Up Reserve

Regulate Up reserve consists of a fast acting generation that can ramp up quickly to increase the net frequency. Alternatively, a considerable high load that can decrease quickly can be implemented. Using loads to regulate up reserves has not been in high demand because a high load often translates to a high cost. It is very common to use co-generation for up-control. However, when there is urgent need for up regulation, and electricity prices are very low, it can be advantageous to use this solution. As can be seen in Figure 6 above, a negative price is possible. This means that one will receive money to absorb power. Although it rarely occurs, prices of about $200.00/MWh have been recorded [18]. The proprietor will buy, or get paid to absorb a certain amount of capacity, and report the load for operation. Now the grid-manager will automatically decrease the load when the net frequency falls.

2.3.2 *Regulate Down Reserve*

Regulate Down reserve is the exact opposite of the up-control and is very attractive for operators. Usually it consists of generators that can decrease generation. Alternatively a controllable load resource can be used that can quickly increase load. Either solution can be reported in for duty and power can be purchased or sold for operation.

2.3.3 *Combined Control*

Combined control is a combination of regulate-up-and-down control, to both increase and decrease the grid frequency. This type of control is not very common for operators that solely rely on either generation or consumption; but for those operators that employ both solutions, this could be a very attractive way to generate heat at a very low cost.

2.3 Effects of Wind Turbines

The quickly increasing number of wind turbines in the grid will result in a decreasing number of conventional power plants, requiring new methods of load-frequency control. Primary frequency control with wind turbines is more difficult than conventional generators due to the lack of inertial feedback caused by the smaller generator size. Often wind turbines are coupled to other forms of generation that can provide back up and primary control [19]. To be able to use the control reserves of these back-up generators, they have to be active in the net [20]. The Electrical Power Processing unit of Delft University of Technology in the Netherlands proposes a combination of wind turbines and fuel cells in a paper from 2006 [21]. In this model the fuel-cells are used as a back-up for power generation and as a source of load-frequency control. Fuel cells directly convert fuel and an oxidant into electricity, achieving higher efficiencies than conventional internal combustion engines [22]. There are several types of fuel cells, distinguished by the oxidant used. Solid Oxide Fuel Cells operate at a high temperature (700 to 1000 °C) and offer the possibility of co-generation to produce additional power through thermal energy. The solution proposed in [21] is demonstrated with two time-domain simulations. The paper concludes that in interconnected power systems the inertia will be larger, causing the change of frequency to be smaller. Smaller systems, particularly in low load situations and during high wind speeds, might experience more volatility. Time-domain simulations show that it is very feasible to have a combination of fuel-cells and wind-turbines supporting each other [21]. In case of frequency droops, the rotating mass of the wind-turbine can be used to support the primary frequency for a short period, thus allowing time for the fuel-cell to respond.

Chapter 3: High-Voltage Electrode Boilers

An alternative to the implementation of fuel cells or other forms of generation in combination with wind turbines is to install fast responding loads. A rather new load that has been implemented is the high-voltage electrode boiler. The concept of an electrode boiler is simple; it is a boiler that passes an electric current through electrodes immersed in a liquid. The liquid acts as a resistive medium that completes the circuit between the electrodes.

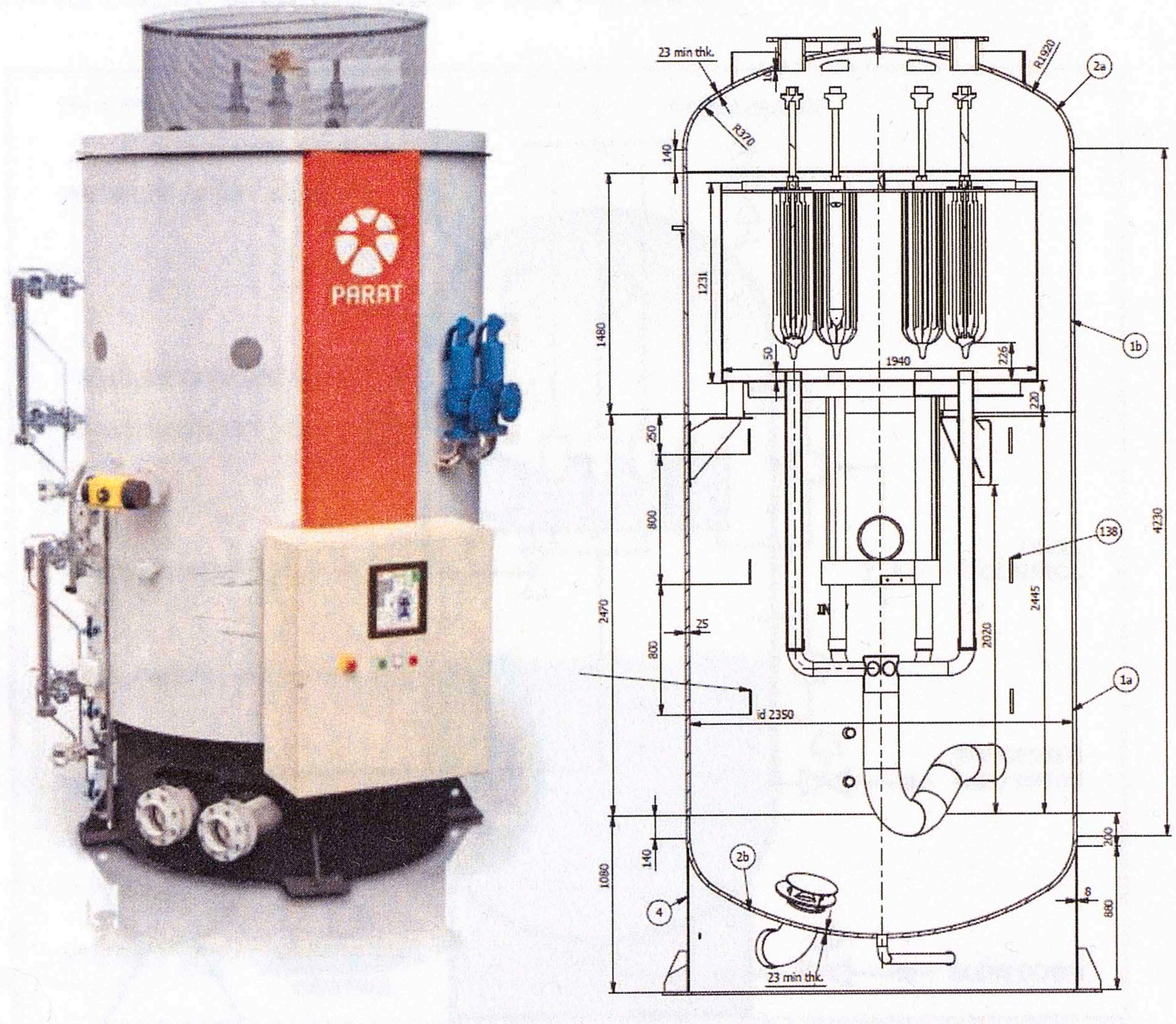

Figure 7 PARAT IEH Electrode Boiler

The resistance of said liquid converts the electric current into thermal energy. It depends on the same concept as electric arc furnaces used to produce aluminum, first patented in 1878 by Sir William Siemens. In this thesis one specific type of electrode boiler is evaluated, the PARAT IEH from the Norwegian boiler manufacturer PARAT Halvorsen AS, (see Figure 7). PARAT has been manufacturing and installing electrode boilers for several decades. From 2006, an alliance began with the Danish company, AS Scan, and the first electrode boiler for primary frequency load control was commissioned. As of March 2014, seven boilers are operational in Denmark and six more boilers are being commissioned in Germany. There are two distinct methods of using the thermal energy from an electrode- boiler, either in the form of hot water or steam. All of the Danish boilers are implemented as hot water boilers, while the German boilers are operated as steam boilers as can be seen in Figure 8 and Figure 9.

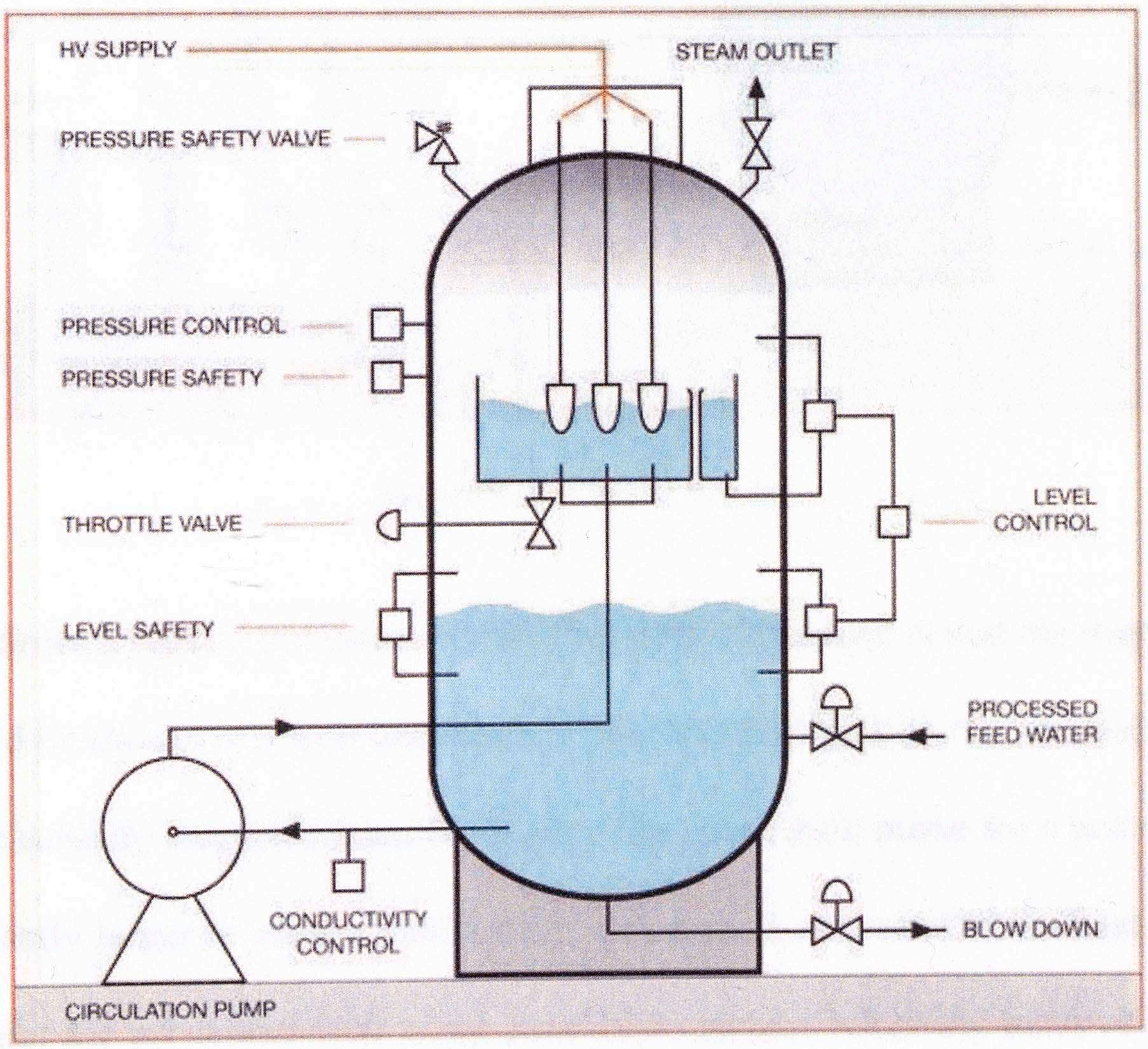

Figure 8 Steam System

In a steam boiler, shown in Figure 8, thermal energy is extracted in the form of steam from the top of the boiler and the circulation circuit is a closed loop. Processed feed water maintains nominal water levels in the boiler based on feedback from the water level control circuit. An automatic blow down system removes any sediments from the bottom of the boiler which can cause increases in conductivity of the water.

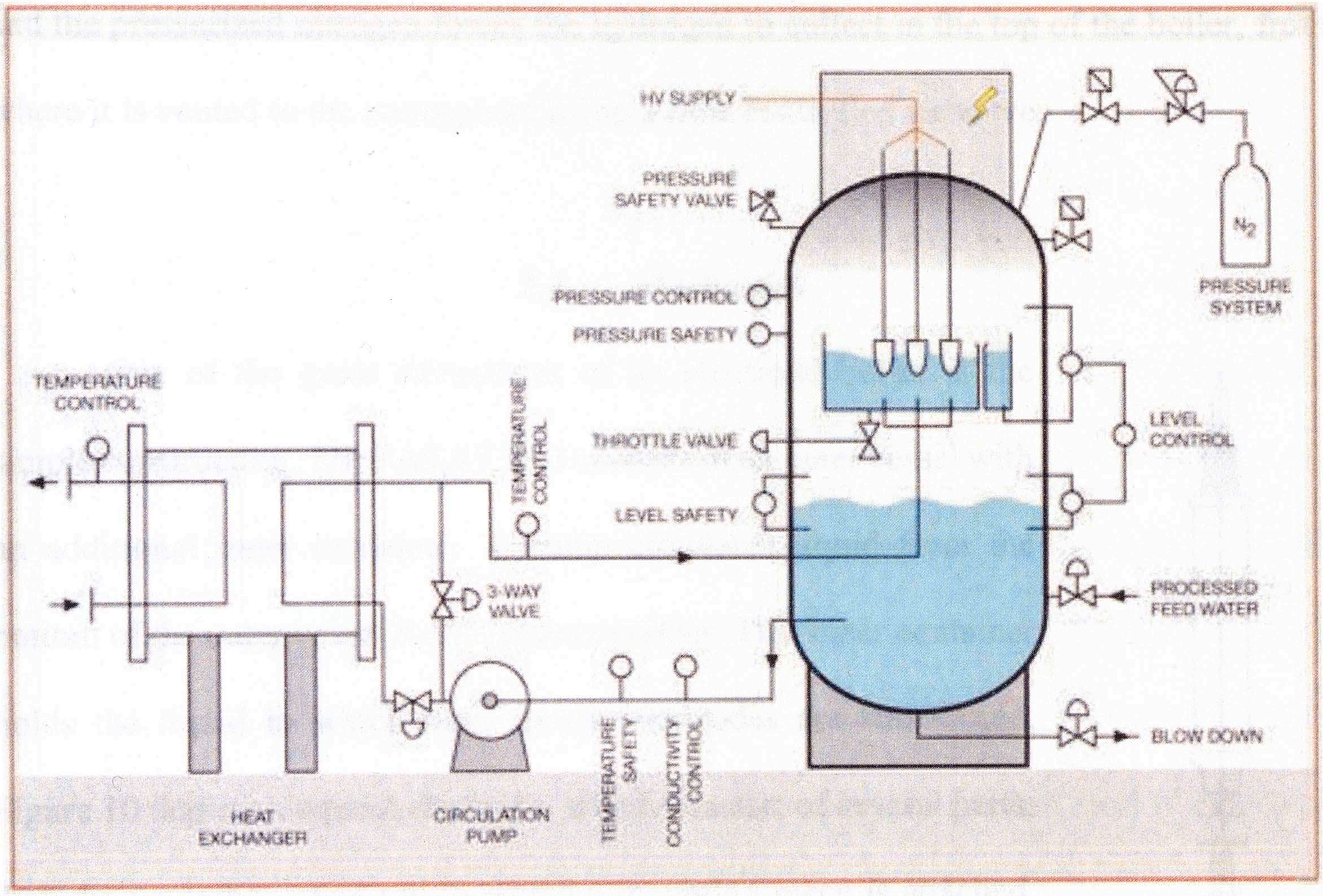

Figure 9 Hot Water System

Figure 9 shows a typical hot water boiler. The main difference is that the thermal energy is extracted by means of a heat exchanger, such that the liquid in the internal circulation loop is not actually extracted from the boiler. The circulation pump for a hot water boiler is significantly larger to ensure that sufficient energy is delivered to the heat exchanger. In this boiler the processed feed water controller remains relatively inactive because no water is extracted from the boiler. Under normal circumstances, boiler conductivity is constant so no sediments are to be removed from the bottom of the boiler. The boiler is pressurized with nitrogen; this removes all oxygen and hydrogen from the boiler.

Excessive oxygen can cause corrosion in the boiler, circulation lines and heat exchanger. Corrosion can cause leaks and the efficiency of a heat exchanger affected by rust will fall significantly. Small amounts of hydrogen are produced when the boiler is in operation, and the pressurized nitrogen forces the hydrogen to collect in the top of the boiler, from where it is vented to the atmosphere using a time controlled air valve.

3.1 Mechanics

One of the great advantages of an electrode boiler is the simple construction. The PARAT IEH consists of an outer vessel with an additional inner container. A pump circulates liquid from the bottom of the outer vessel to the inner container. This inner container holds the liquid in which three or six electrodes are submerged. Figure 10 depicts a typical electrode, which consists of several parts; including a carbon steel rod to which a mounting piece is attached. The mounting piece holds twelve cast iron electrode rods arranged in a circular pattern, with an additional central electrode rod.

The electrode sets are mounted inside the boiler in a circular fashion such that the distance between each neighboring electrode is equal.

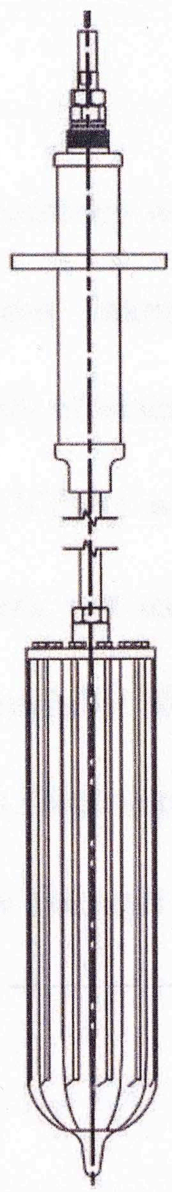

Figure 10
PARAT
Electrode

Throughout the inner container, 18 to 36 neutral electrodes are situated around the main electrodes, see Figure 11.

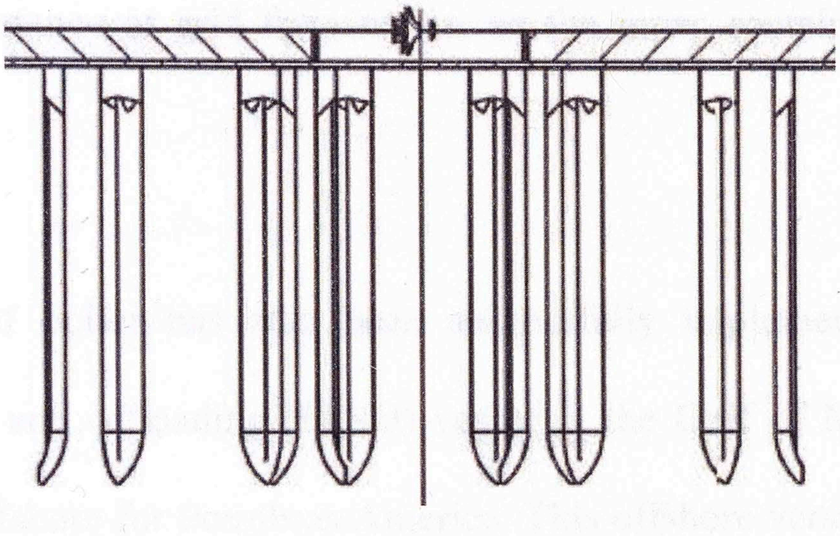

Figure 11 Neutral Electrodes

The neutral electrodes are directly bolted to the inner container. These electrodes were developed in collaboration between PARAT Halvorsen and "Norges teknisk-naturvitenskapelige universitet" (NTNU). NTNU is the Norwegian University of Science and Technology. Through implementing neutral electrodes, PARAT and NTNU were able to reduce the electrode wear significantly. Traditional electrode boilers, not using neutral electrodes, that are in operation more than 4000 hours a year, especially when operating around low loads, show significant signs of wear on the electrodes. Worn down electrodes have to be replaced annually to avoid asymmetric current flow through the active electrodes.

3.2 Electrical

The typical operating voltage of a PARAT IEH is between 10,000 and 11,500 VAC arranged in three phases. Operated in land-based installations, the load is perfectly symmetrical. Each of the electrodes, be it three or six, are submersed equally. Because of this balanced load, there is no need for a neutral conductor. As such, the inner container is electrically isolated from the outer vessel by TEFLON® isolators. TEFLON® has an extremely high resistance at grid frequencies, so the inner container functions as an isolated neutral.

This type of boiler has also been successfully implemented on a floating production, storage and offloading (FPSO) vessel in the Gulf of Mexico, owned and operated by BW Offshore for Petrobras America. This offshore version of the electrode boiler is equipped with six electrodes. The two electrodes for each phase are deployed opposite each other, so during sway and surge motions of the vessel, each phase is still submerged equally. The inner container and the electrode are also over-dimensioned to allow for more sway and surge. An obvious limitation is a theoretical maximum allowable sway and surge, which is actually set to 14° in all directions. This application has been successfully patented by PARAT, and PARAT is still the only company in the world to have implemented such a solution.

As previously mentioned, the improved performance from the use of neutral electrodes comes from the fact that the neutral electrodes ensure the sum of the currents is zero at all times. Before the neutral electrodes were suggested, the wear down of electrodes could result in an imbalance of load, which again could result in a residual neutral current. There are other situations that could result in a residual neutral current, the obvious situation being the loss of one or two phases. A main circuit breaker is employed to engage and disengage the boiler on demand and secures the maximum current drawn by the boiler. The main breaker would also disengage with a loss of phases.

3.3 Control System

The control system for the PARAT IEH consists of a SIEMENS S7 300 Programmable Logic Controller with a Beijer Electronics iX Human Machine Interface. In Figure 12 a typical control cabinet as supplied by PARAT Halvorsen AS. The conventional electrode boiler as delivered by PARAT has been controlled by PLC for 20 years. The PLC program for these electrode boilers was rewritten in 2007 and significantly revised in 2009. The control philosophy for a conventional hot water PARAT IEH boiler consists of many components each with its own dedicated controller.

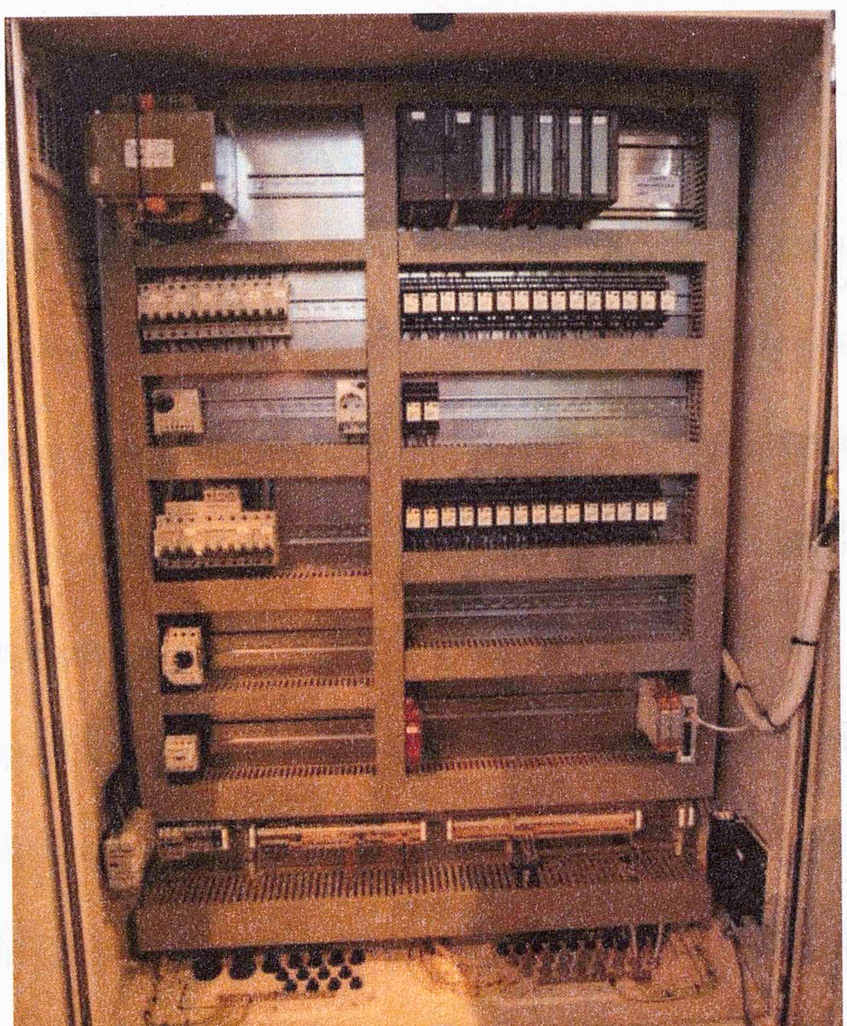

Figure 12 Typical PLC Control Cabinet

The following components are part of the PARAT IEH boiler control philosophy:

- Power Controller - Ensures actual absorbed power is equal to the external power set-point that ensures proper load-frequency control by altering the upper water level set-point.
- Boiler Supply Temperature/Pressure Controller - Ensures temperature or pressure is sufficiently high for use by the consumer, but is within boiler specifications. This is achieved by limiting the output from the power controller.
- Upper Level Controller - Ensures actual upper water level is equal to the set-point from the power controller. The water level is altered by raising and lowering the overflow pipe in the inner container.
- Total Level Controller - Ensures the total boiler level, which is the total volume in both the outer vessel and the inner container, is sufficient for operation. For steam applications this is done with a continuous controller altering the speed of a feed-water pump, while for hot-water applications only make-up water is added to account for any water losses due to bottom blow down.
- Pressure Controller – For use in a hot-water boiler. Ensures boiler pressure is high enough to achieve needed temperature but is within boiler specifications. To achieve temperatures over 100 °C the boiler needs to be pressurized to avoid the water from boiling and steam production.

- Conductivity Controller - Ensures conductivity of the boiler water is within operational limits. High conductivity may cause overshoots of power or even arcing; low conductivity will cause decrease of power capacity.
- Secondary Temperature Controller – For use in hot-water systems. Ensures temperature delivered to secondary water distribution network is high enough for the consumer, while assuring enough energy is consumed from boiler.

The following sections discuss each controller in depth.

3.3.1 Power controller

In conventional electrode boilers, the power controller is only used to limit the absorbed power while maintaining boiler pressure or temperature set-points. In the PARAT IEH system, when it is used for load-frequency control, the power controller is the master of a cascaded controller. The cascaded sequence is shown in Figure 13. The slave of this controller is the upper water level controller.

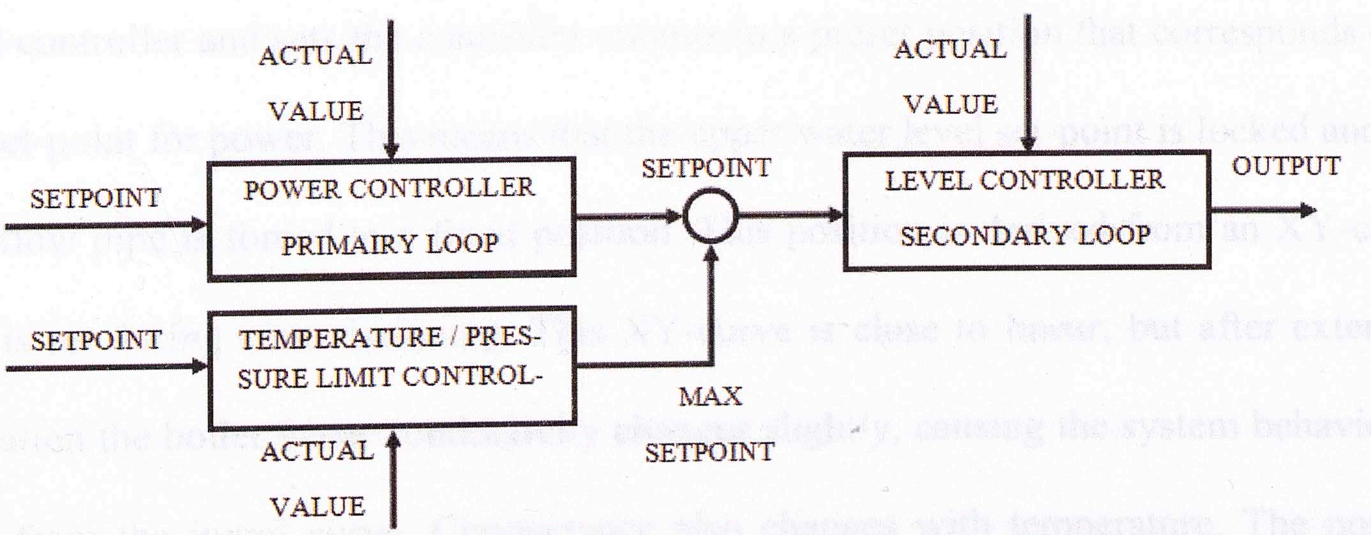

Figure 13 Cascaded Power Level Controller

The power controller receives an external set-point from the load-frequency controller and has two basic modes of operation: normal operation and load-frequency control. In normal mode, the controller works as a regular proportional-integral-derivative (PID) controller and tries to get the absorbed power to reach the set-point as quickly and smoothly as possible. Depending on the current electrical grid situation, this set-point can be very volatile and change from 0% load to 100% load in a single cycle (100 ms). When the boiler is being utilized for primary load-frequency control, the actual absorbed power has to reach the new set-point within 30 seconds of the set-point change. It is also possible that the boiler is used for secondary control. During secondary control, the power controller will smooth out the change in set-point such that the change per second does not increase beyond certain limits. These limits are specified by the grid-manager and are usually the maximum power divided by 150 seconds. For a 10 MW boiler this means a maximum change of 67 kW a second.

Primary control is automatically activated when the change from one cycle to the next exceeds a percentage set by the operator. When activated, it locks the power and the level controller and sets the controller outputs to a preset position that corresponds with the set-point for power. This means that the upper water level set-point is locked and the overflow pipe is forced to a fixed position. This position is derived from an XY-curve that is set during commissioning. This XY-curve is close to linear; but after extended operation the boiler water conductivity changes slightly, causing the system behavior to drift from the initial curve. Conductance also changes with temperature. The normal operation temperature should not change too much, but the actual temperature around the electrodes is expected to fluctuate more aggressively.

The minimum output from the power controller is limited by an operator set-point. If the level in the upper container becomes too low, the electrodes will no longer be submersed in water. A gap will form between the electrodes and the water, causing an open loop between the electrodes and possible load imbalances. If the gap is relatively small, less than 3 mm, there is a chance that sparks will form between the electrode tips and the surface of the water. There is a theoretical possibility that if the time-controlled hydrogen relief fails and a hydrogen bubble is formed in the top of the boiler, the hydrogen may be ignited by the sparks.

The maximum output is limited by an additional XY-curve. The curve is similar to the set-point curve; it is designed to prohibit the absorbed power from overshooting the set-point. The main circuit breaker is often set to trip at 105 or 110% of the rated boiler power. If the actual power absorbed by the boiler exceeds these set-points and a trip occurs, the load will fall from the electrical grid, which can have detrimental effects to the frequency of the grid.

3.3.2 Boiler Supply Temperature / Pressure Controller

If the boiler is implemented as a hot water boiler, the secondary loop for the cascaded controller is the boiler supply temperature. The boiler supply temperature is measured directly after the outlet of the boiler, upstream of the main circulation pump.

For steam boilers, the secondary loop is the boiler pressure. In conventional industrial applications, this temperature or pressure would be the primary control loop for the cascaded boiler control; however, in load-frequency control, the temperature or pressure controller is only used to limit the manipulated output from the power controller. The absorbed power has high priority, but in case of a boiler temperature or pressure that approaches the design limits of the boiler, the power controller will be limited to ensure a decrease in temperature or pressure. If limiting the power controller does not decrease temperature or pressure and it rises over the maximum working set-point, the boiler will automatically disengage the main circuit breaker. The breaker re-engages when the boiler temperature or pressure has sufficiently decreased. Under normal operation, it is very undesirable that the temperature/pressure controller limits the power controller, which can be avoided by ensuring that the boiler can dump all thermal energy it generates to the consumer grid.

In case a critical failure occurs and multiple safety devices fail, without the boiler ceasing operation, pressure can build inside the boiler. To ensure that the boiler pressure will never exceed the boiler design specifications, multiple pressure safety valves are fitted on the boiler. Each of these valves can dump the amount of steam that the boiler is theoretically able to produce.

3.3.3 Upper Level Controller

The upper water level controller is the slave in the cascaded control loop and receives its set-point from the power controller. A drainpipe is mounted in the center of the inner container, the height of which is manipulated, causing the level to increase and decrease proportionally with the position of the drainpipe. When the current water level is lower than the set-point, the circulation will be ramped up to ensure enough water is pumped from the outer vessel to the inner container. The drainpipe diameter is designed such that the actual boiler level is drained with very little delay time. The minimum and maximum controller outputs are limited such that the water level cannot fall to low, causing arcing, or go too high causing power overshoot.

The first revision of the control system for implementing load-frequency control was made in 2010 and has since undergone continuous improvements. The major change between the conventional control program and the load control program is a series of six XY-curves that are predetermined at the time the system is commissioned. The first curve is used to limit the level set-point that comes from the power and temperature controllers according to the load demand. The second curve is similar, but limits the output from the water level controller. A third curve is used to preset the water level controller output with changes in load demand that are greater than 25%. The fourth curve is used to set the speed of the primary circulation pump according to the power currently absorbed by the boiler. When the boiler is in low load, the water level in the container is very low. If the circulation pump is running at a high speed water can spray on the electrodes. To ensure sufficient circulation to deliver as much thermal energy as possible to the consumer network during higher boiler loads, the speed of the circulation pump is increased. The fifth curve reduces the set-point for the return temperature into the boiler with higher boiler loads. This is to ensure enough thermal energy can be absorbed by the water without causing a temperature shut-down and low secondary temperatures during low loads. The last curve controls the opening of the shut off valve on the secondary side of the heat exchanger to control the flow through the consumer network. This is to ensure the temperature to the consumer accumulation tanks is consistent. Low temperatures cause imbalance in the tanks, effectively decreasing the thermal capacity. High temperatures can cause shut-downs and damage to the equipment.

3.3.4 Total Level Controller

The total level is calculated by adding the active water volume of the upper and lower containers. The active volume is determined by the container diameter and the active control height, which is limited by the nozzle placement of the water level gauges. When water is barely visible in the bottom of the level gauge, the water level indicated by the level transmitter is 0%. When the water level is in the top of the level gauge, the indicated level is 100%. The level gauge has an active length of about 1000 mm. The container diameter depends on the rated boiler capacity. For a 20 MW boiler utilizing six electrodes, the outer shell has a diameter of 2350 mm and the inner water container has a diameter of 1940 mm. For the water volume to be accurate, the volume of the electrodes has to be subtracted from the equation. Each electrode has a volume of 0.066 m^3. With this data, the total water volume can be determined:

$$V_{total} = V_{lower} + V_{upper} - V_{electrodes}$$

$$= \pi h \left(\frac{d_{lower}}{2}\right)^2 + \pi h \left(\frac{d_{upper}}{2}\right)^2 - 6(0.066)$$

$$= \pi \cdot 1 \cdot \left(\frac{2.350}{2}\right)^2 + \pi \cdot 1 \cdot \left(\frac{1.940}{2}\right)^2 - 6(0.066)$$

$$= 4.34\ m^3 + 2.96\ m^3 - 0.39 m^3 = 6.91 m^3$$

Using the ratio between the lower and upper water volume, the total water level noted as a percentage is calculated:

$$L_{total} = \frac{V_{lower}}{V_{total}} L_{lower} + \frac{V_{upper} - V_{electrodes}}{V_{total}} L_{upper}$$

$$= \frac{4.34}{6.91} L_{lower} + \frac{2.57}{6.91} L_{upper}$$

$$= 62.8\% \cdot L_{lower} + 37.2\% \cdot L_{upper}$$

For a PARAT IEH system implemented as a steam boiler, a continuous total water level is essential, because large quantities of water are extracted in the form of steam. A steam boiler is fitted with one or more feed-water pumps with speed control or feed-water pumps combined with control valves. To ensure optimal operation, the total water level should be as high as possible. The maximum level is determined by the water level in the lower container, which cannot exceed a water level of 95% at any time. When there is no operation of the circulation pump, all water will collect in the lower container. If the lower water level exceeds 95%, a boiler shut-down is initiated to prevent the possibility of a short-circuit of the outer shell and inner container through the water. Using the formula derived, we get a maximum total water level of:

$$L_{total} < 62.8\% \cdot L_{lower}$$
$$< 62.8\% \cdot 95\%$$
$$< 59.7\%$$

To allow for additional pre-alarm limits and small deviations of the set-point, the actual set-point should be set around 55%.

When a PARAT IEH system is used as a hot-water system, no water is extracted from the boiler, other than small amounts of water that are expelled from the boiler by the bottom blow down process. To ensure a sufficient total water level, a single make-up water pump is used with a simple start/stop logic. Start and stop levels typically are around 50% and 55% respectively.

Regardless of the type of implementation, a boiler shut-down will be initiated when the water level in the lower container comes under 5%. A water level that low can cause air to be sucked in to the circulation pump, which can cause a stall in circulation or damage to the pump. When the lower water level becomes too low, the circulation pump is stopped and a shut-down is initiated.

3.3.5 *Pressure Controller*

An electrode boiler implemented as a hot-water boiler is pressurized by means of nitrogen. Pressurizing is performed to increase the temperature range of the boiler. At atmospheric pressure, the boiling point for water is approximately 100 °C.

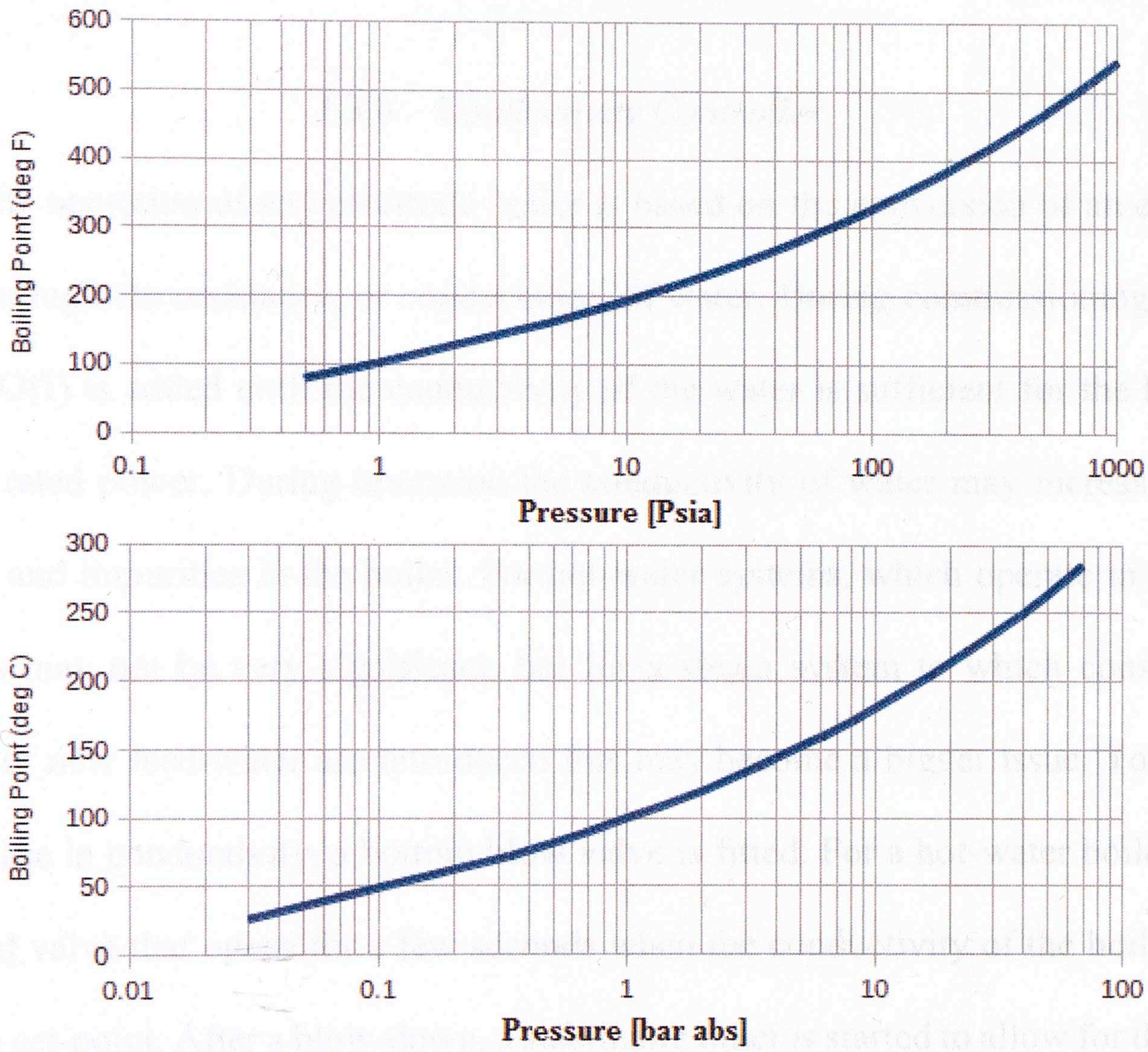

Figure 14 Boiling Temperature vs. Absolute Pressure

The maximum rated temperature for a typical hot-water boiler is 115 °C. To be able to reach this temperature, an absolute pressure of at least 1.65 bar is needed, as shown in Figure 14.

Typically, the boiler is pressurized to about 2 bar relative pressure, which corresponds to about 3 bar absolute pressure. Pressurizing is done by means of nitrogen, because of its inert properties. It suppresses the forming of sparks, and forces oxygen and hydrogen to the top of the boiler from where they can be expelled by means of a pressure relief valve. The pressure relief valve is time controlled, and typically opens for two seconds after 8 hours of operation.

3.3.6 Conductivity Controller

The operation of any electrode boiler is based on the conversion of an electrical current through the resistance, or conductance, of water. During commissioning, caustic soda (NaOH) is added until the conductivity of the water is sufficient for the boiler to reach its rated power. During operation the conductivity of water may increase due to sediment and impurities in the boiler. For hot-water systems, which operate in a closed loop, this may not be very significant, but for a steam system to which considerable amounts of new feed-water are introduced this may become a bigger issue. To counter this increase in conductivity, a bottom blow valve is fitted. For a hot-water boiler this is a solenoid valve that opens for a few seconds when the conductivity of the boiler water exceeds a set-point. After a blow-down, a stabilizing timer is started to allow for the boiler conductivity to settle. The blow-down will result in a drop of the water level, which will cause the make-up pump to start, adding new water with a very low conductivity (see section 2.5.9). Two or more blow-down cycles may be needed for the water level to sink sufficiently to get below the make-up pump start limit.

A steam boiler is fitted with a continuous blow-down valve, manipulated by a PID-controller. One of the effects of extracting steam and introducing large amounts of feed-water to a boiler is the increase in conductivity. Even though feed-water has a low conductivity, the continuous extracting of water in the form of steam causes minerals and impurities to settle. This makes a continuous bottom blow-down necessary.

3.3.7 Return Temperature Controller

A return temperature transmitter is fitted in the return line from the heat-exchanger to the boiler. The return temperature is determined by the amount of thermal energy that is delivered to the secondary consumer network through the heat-exchanger. This amount of energy is determined by the volume of water that is pumped through the heat-exchanger, and is controlled by adjusting a set of butterfly-valves interconnected to function as a three-way control valve. The temperature set-point is adjusted by an XY-curve as a function of the current power generated by the boiler. A lower power generation will result in a higher set-point to achieve a sufficiently high supply temperature such that the temperature in the secondary consumer network can be guaranteed. At higher boiler loads, the set-point is lowered to allow for an increased thermal energy buffer in the water.

3.3.8 Secondary Supply Temperature Controller

The secondary supply temperature is the temperature measured after the heat-exchanger on the secondary consumer grid. When the boiler is in operation and the three-way control valve mentioned in the previous section is opened, a shut-off valve will open proportionally with the opening of the three-way control valve. The proportion is determined by an XY-curve and is set during commissioning, such that the secondary supply temperature does not fall too low. When the shut-off valve is opened, the secondary circulation pump is started; a larger opening of the valve will automatically result in an increased volume of circulated water. The secondary circulation pump is frequency controlled and a PID-controller is implemented to ensure the secondary supply temperature does not exceed the set-point too much.

3.3.9 Feed-Water / Make-Up Water Supply

A key parameter that determines the power consumption of an electrode boiler is the conductivity of the water. To ensure correct operation of the boiler, it is essential that the feed-water, or make-up water, entering the boiler has a very low conductivity. To ensure sufficient low conductivity, the water is treated by a series of filters.

The first stage of the water treatment system is a simple cartridge filter that removes solids and bigger impurities like sand or rust particles. The next stage consists of a softening filter that softens the water. A softening filter is filled with small beads that are negatively charged and bonded to positively charged sodium ions. When water flows through the filter, the calcium and magnesium ions swap places with the sodium. A reverse osmosis filter consequently demineralizes the softened water. "Osmosis is the passage or diffusion of water or other solvents through a semipermeable membrane that blocks the passage of dissolved solutes [23]" For a reverse osmosis application the unfiltered water is pressurized causing the water molecules to pass through the membrane while salt molecules remain in the 'dirty' side of the filter. The resulting water is between 1 and 20 μS in conductivity. Constant monitoring of the conductivity is performed by a conductivity analyzer, which is situated in the circulation stream. The process value from the analyzer is temperature compensated and shows the conductivity for 25 °C.

For hot water applications, the boiler is filled and an initial startup is performed. Because of corrosion and other impurities in the boiler, the conductivity will likely rise. The goal during commissioning is to achieve the rated power consumption of the boiler with a level that is just under 100%. If the power consumption is at the boiler rating, the water in the boiler has to be purged with low conductivity water. In most cases the conductivity will be too low and caustic soda (NaOH) is added to increase it. When the conductivity of a hot water boiler is adequate, generally no new water or caustic soda has to be added until the boiler is drained.

For steam boilers, there is a need for constant feed water supply. In the majority of the applications, this feed water comes in the form of return condensate from the consuming process; but in some cases all or part of the steam is consumed during the process. Depending on the size of the boiler, large scale reverse osmosis filters are needed to supply enough feed water.

Chapter 4: Methods

As mentioned in previous sections, the correct operation of an electrode boiler is largely dependent on the conductivity of the water. Deviations of set-points and inaccuracy of the controllers are caused by the changes of the boiler water conductivity. Increased conductivity caused by sediments and other contamination of the water are sufficiently handled the conductivity controller, but changes caused by temperature swings have never been investigated. To understand these changes in conductivity, mathematical analysis is necessary.

4.1 Analysis

One obvious concern associated with the operation of high-voltage electrode boilers is the chance of personal or material damage because of direct exposure to the high-voltage. For information purposes, a hypothetical case is presented to calculate the current to ground.

In case of destructive failure, the maximal achievable voltage from one phase to ground is given by:

$$V_{L-GND} = \frac{V_L}{\sqrt{3}}$$

$$= \frac{11{,}500}{\sqrt{3}}$$

$$= 6{,}640\ V$$

where V_L is the line voltage.

The resistance consists of the volume of the water and the electrolytic conductivity or specific conductance of this liquid.

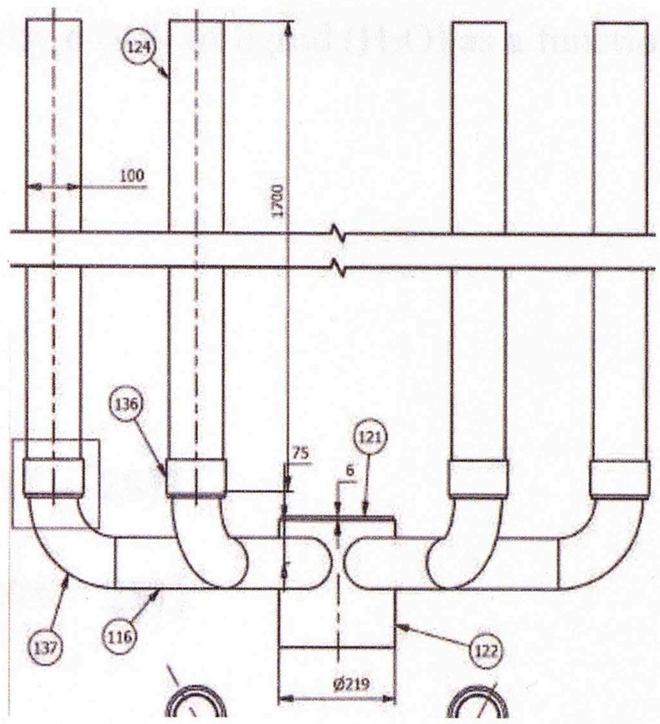

Figure 15 TEFLON® Pipes under Electrodes

The major paths of conduction are the circulation and drain pipes, as shown in Figure 15. The pipes are constructed from TEFLON®, which is a material with immense dielectric properties at line frequencies; therefore the conductivity of this material can be neglected. The conductivity of liquid is temperature dependent. For the following calculations, the worst-case situation is used where the conductivity exceeds the design parameters. The maximal achievable temperature that does not result in a shutdown is 204 °C for a steam boiler, and 115 °C for a hot water boiler. Similarly, the maximal allowable conductivity of the water at room temperature (25°C) is determined to be 28 μS for a steam boiler and 60 μS for a hot water boiler. The conductivity is a very important part of the boiler operation, and is explored in-depth in Chapter 5. Resistance calculations in case of a destructive short-circuit are in the following section.

4.1.1 Resistance Calculation Steam Boiler

- Conductivity **σ** (μS) of liquid (H_2O) as a function of temperature T (°C)

$$\sigma_{25°C} = 28\ \mu\frac{S}{cm}$$

$$T = 204°C$$

$$\sigma = \sigma_{25°C} \cdot \left(1 + 0.02(T - 25)\right)$$

$$= 28 \cdot \left(1 + 0.02(204 - 25)\right)$$

$$= 128.2\ \mu\frac{S}{cm}$$

- Resistance R (Ω) in each of six circulating pipes with inner diameter d = 80 cm and length L = 170 cm

$$A = \pi \cdot \left(\frac{d}{2}\right)^2$$

$$= \pi \cdot \left(\frac{8}{2}\right)^2$$

$$= 50.27cm^2$$

$$R_{CIRC} = \frac{L}{\sigma \cdot A} = \frac{170}{128.2 \cdot 10^{-6} \cdot 50.27}$$

$$= 26{,}370\Omega$$

- Resistance R (Ω) in drain pipe with inner diameter d = 2 cm and length L = 70 cm

$$A = \pi \cdot \left(\frac{d}{2}\right)^2$$

$$= \pi \cdot \left(\frac{2}{2}\right)^2$$

$$= 3.14 cm^2$$

$$R_{DRAIN} = \frac{L}{\sigma \cdot A}$$

$$= \frac{70}{128.2 \cdot 10^{-6} \cdot 3.14}$$

$$= 173{,}750\Omega$$

- Total Resistance R (Ω) in six circulation pipes and drain pipe

$$R_{TOT} = \frac{1}{\frac{6}{R_{CIRC}} + \frac{1}{R_{DRAIN}}}$$

$$= \frac{1}{\frac{6}{26{,}370} + \frac{1}{173{,}750}}$$

$$= 4{,}286\Omega$$

Combining this data results in a worst-case ground current for an electrode boiler operated as steam boiler:

$$I_{GND} = \frac{V_{L-GND}}{R_{TOT}}$$

$$= \frac{6{,}640}{2{,}136}$$

$$= 1.55A$$

4.1.2 Resistance Calculation Hot Water Boiler

- Conductivity **σ** (μS) of liquid (H_2O) as function of temperature T (°C)

$$\sigma_{25°C} = 60\ \mu\frac{S}{cm}$$

$$T = 115\ °C$$

$$\sigma = \sigma_{25°C} \cdot \left(1 + 0.02(T - 25)\right)$$

$$= 60 \cdot \left(1 + 0.02(115 - 25)\right)$$

$$= 168\ \mu\frac{S}{cm}$$

- Resistance R (Ω) in each of six circulating pipes with inner diameter d = 80 cm and length L = 170 cm

$$A = \pi \cdot \left(\frac{d}{2}\right)^2$$

$$= \pi \cdot \left(\frac{8}{2}\right)^2$$

$$= 50.27cm^2$$

$$R_{CIRC} = \frac{L}{\sigma \cdot A}$$

$$= \frac{170}{168 \cdot 10^{-6} \cdot 50.27}$$

$$= 20{,}129\Omega$$

- Resistance R (Ω) in drain pipe with inner diameter d = 2 cm and length L = 70 cm

$$A = \pi \cdot \left(\frac{d}{2}\right)^2$$

$$= \pi \cdot \left(\frac{2}{2}\right)^2$$

$$= 3.14cm^2$$

$$R_{DRAIN} = \frac{L}{\sigma \cdot A}$$

$$= \frac{70}{168 \cdot 10^{-6} \cdot 3.14}$$

$$= 132{,}629\Omega$$

- Total Resistance R (Ω) in six circulation pipes and drain pipe

$$R_{TOT} = \frac{1}{\frac{6}{R_{CIRC}} + \frac{1}{R_{DRAIN}}}$$

$$= \frac{1}{\frac{6}{20{,}129} + \frac{1}{132{,}629}}$$

$$= 3{,}272\Omega$$

Combining this data results in a worst-case ground current:

$$I_{GND} = \frac{V_{L-GND}}{R_{TOT}}$$

$$= \frac{6{,}640}{3{,}272}$$

$$= 2.0A$$

4.2 Temperature Compensation

As shown in the previous equations, the electrical conductivity of all solutions changes as temperature changes; a higher temperature results in a higher conductivity. For every degree of temperature increase, the conductivity increase is about 2% [24]. Most specialized conductivity analyzers available on the market are equipped with active temperature compensation, and the value used for logging and controls is the conductivity at room temperature [25 °C]. Having an active temperature compensation ensures periodic measurements are consistent and can be compared regardless of actual sample temperature.

For the application of water measurements in electrode boilers, consistency is very important to ensure that the NaOH added to the boiler is not increasing the conductivity too much. The increase in conductivity of the water is very rapid, when NaOH with a very low concentration (0.2%) is added. A teaspoon of NaOH solution can increase the conductivity of the entire boiler volume by several μS. The average conductivity of the PARAT IEH, when operated as a hot water boiler, is 60 μS, at 25 °C. When an electrode boiler is being implemented for load-frequency control, the actual load of the boiler can quickly fluctuate from 0% to 100%. Because of these fluctuations, the temperature of a hot water boiler in operation can be between 80 °C and 115 °C. The actual working temperature should not fall below 90 °C, or exceed 110 °C. This translates to an actual conductivity that fluctuates from 132 μS to about 152 μS, as shown in Figure 16. It should be noted that the change in conductivity is linear over the temperature ranges considered in this thesis. The fluctuation in conductivity causes problems in the linearity between the water level around the electrodes and the absorbed power. To counter these fluctuations and to improve the speed and the accuracy of the controller, a new algorithm was devised that accounts for the varying conductivity due to changing water temperatures. The basic idea of the new algorithm is to dynamically adjust the slope of the XY-curves that were initially determined during commissioning of the boiler.

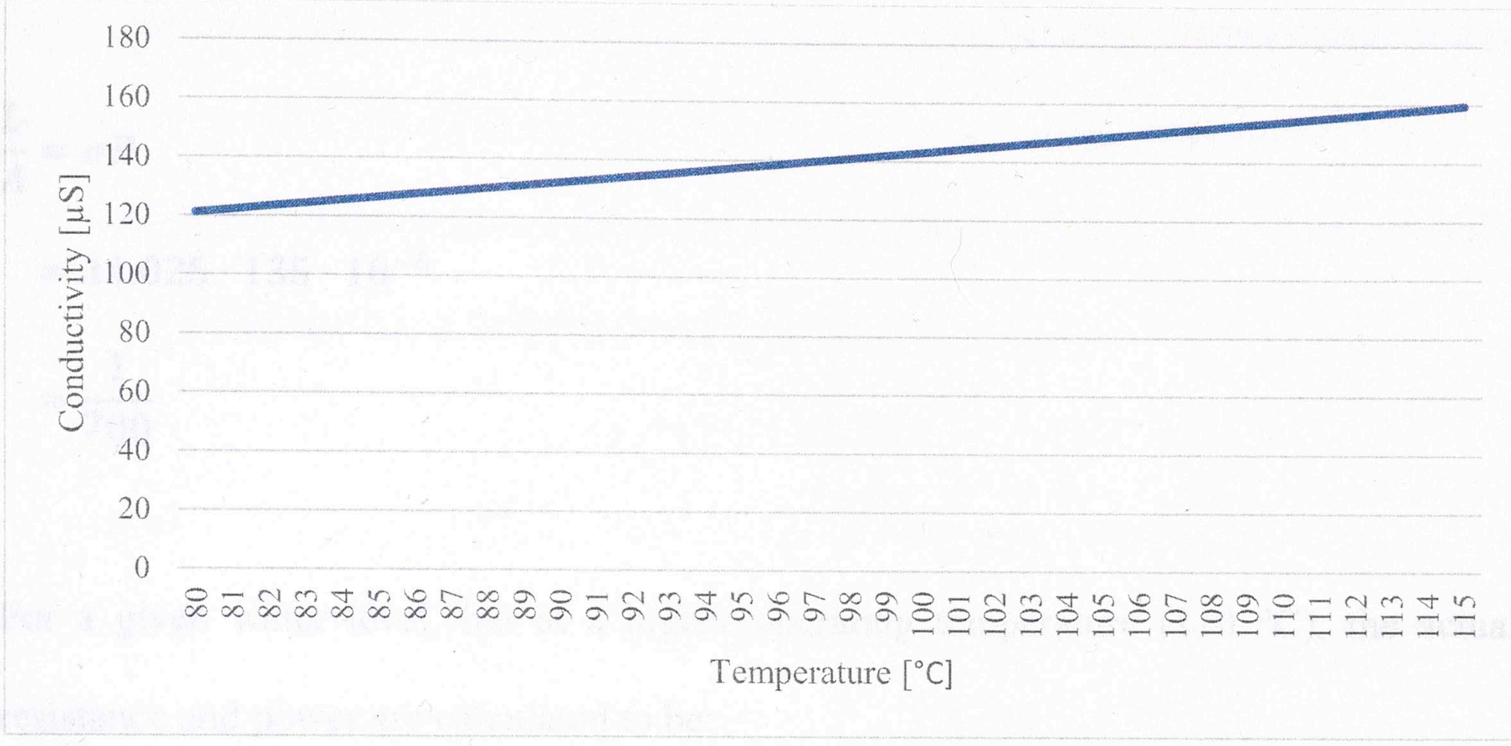

Figure 16 Conductivity Change with Temperature

4.3 Resistivity in Water

The electrodes are terminated in a WYE configuration, with an isolated neutral point. Given this configuration, the actual resistance of the water at full load can be determined. For the calculations, we use a 10 MW boiler running on a 10.5 kV voltage.

$$R = \frac{V^2}{P}$$

$$= \frac{10{,}500^2}{10{,}000{,}000}$$

$$= 11.025\Omega$$

Given the resistance computed above, the ratio between the length and area of the conducting water body at the lowest operating temperature and corresponding conductivity can be determined:

$$\frac{L}{A} = \sigma R$$

$$= 11.025 \cdot 135 \cdot 10^{-6}$$

$$\approx \frac{1}{700}$$

For a given water level, but at a higher operating temperature (110 °C), the actual resistance and power are calculated to be:

$$R = \frac{L}{A} \cdot \frac{1}{\sigma}$$

$$= \frac{1}{700} \cdot \frac{1}{155 \cdot 10^{-6}}$$

$$= 9.247\Omega$$

$$P = \frac{V^2}{R}$$

$$= \frac{10{,}500^2}{9.247}$$

$$= 11.92\ MW$$

Therefore, with an operating temperature changing from 90 °C to 110 °C, a 22% increase, the maximum absorbed power is increased by 1.92 MW, which is a 19.2% increase in power. In practice this means that during commissioning, the initial XY-curves must be determined based on a constant temperature. Ideally, this temperature should remain constant at the lowest allowable operating temperature. This allows the algorithm to ensure that the boiler can achieve full generating capacity at all operating temperatures. Full load has to be achieved at the lowest allowable operating temperature. Figure 17 illustrates the increase in power when water temperature is accounted for. The curves for the two extreme operating temperatures are shown.

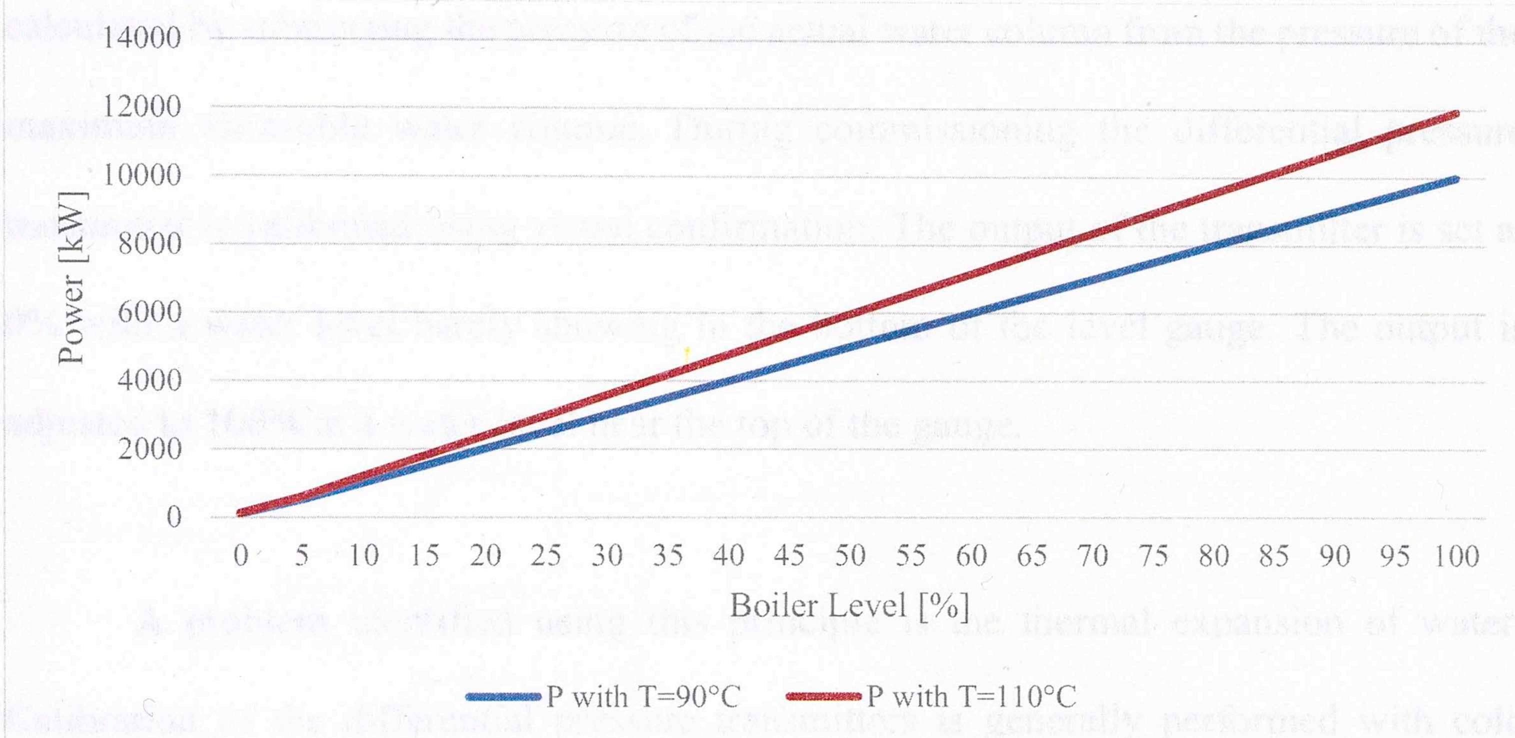

Figure 17 Power Curves at Temperature Extremes

The fact that the increase in power with an increasing temperature is linear allows us to derive an automatic compensation that will alter the actual level set-point from the initial set curves. This compensation has to be able to protect the boiler from overshooting its set-point, protecting the system from unwanted shut downs and improving overall accuracy of the control system.

4.4 Thermal Expansion of Water

The boiler water level is measured by a differential pressure measurement and is represented as a percentage. This percentage is proportional to the length of the level gauge, which is mandatory on any boiler. A differential pressure transmitter simultaneously measures the pressure at the bottom and the top limits of the allowable water level. The top measurement is the reference and is equal to the boiler pressure plus the pressure of the maximal allowable water column. The bottom measurement is equal to the boiler pressure and the current water column. The actual level can therefore be calculated by subtracting the pressure of the actual water column from the pressure of the maximum allowable water column. During commissioning the differential pressure transmitter is calibrated using visual confirmation. The output of the transmitter is set at 0% with a water level barely showing in the bottom of the level gauge. The output is adjusted to 100% at a water level near the top of the gauge.

A problem identified using this principle is the thermal expansion of water. Calibration of the differential pressure transmitters is generally performed with cold water, at room temperature. The change in density of water from 20 °C to the operational temperature of 110 °C is [25]:

$$998.3\frac{kg}{m^3} - 951\frac{kg}{m^3} = 47.3\frac{kg}{m^3}$$

A given level at 20°C, indicated to be 100% by the differential pressure transmitter, will be physically approximately 4.7% higher at 110°C while still indicating 100%. To improve accuracy during operation it is important that the transmitters are recalibrated at operational temperature.

The change in density in the working temperature range from 90°C to 110°C is 1.6%. To guarantee correct operation in the entire working temperature range, this percentage should be taken into account in the proposed algorithm.

4.5 Program Improvements

The software program improvements are applied to the first three curves previously mentioned. These curves are the maximum level set-point curve, the maximum level controller-output curve and the pre-set curve for primary load-frequency control.

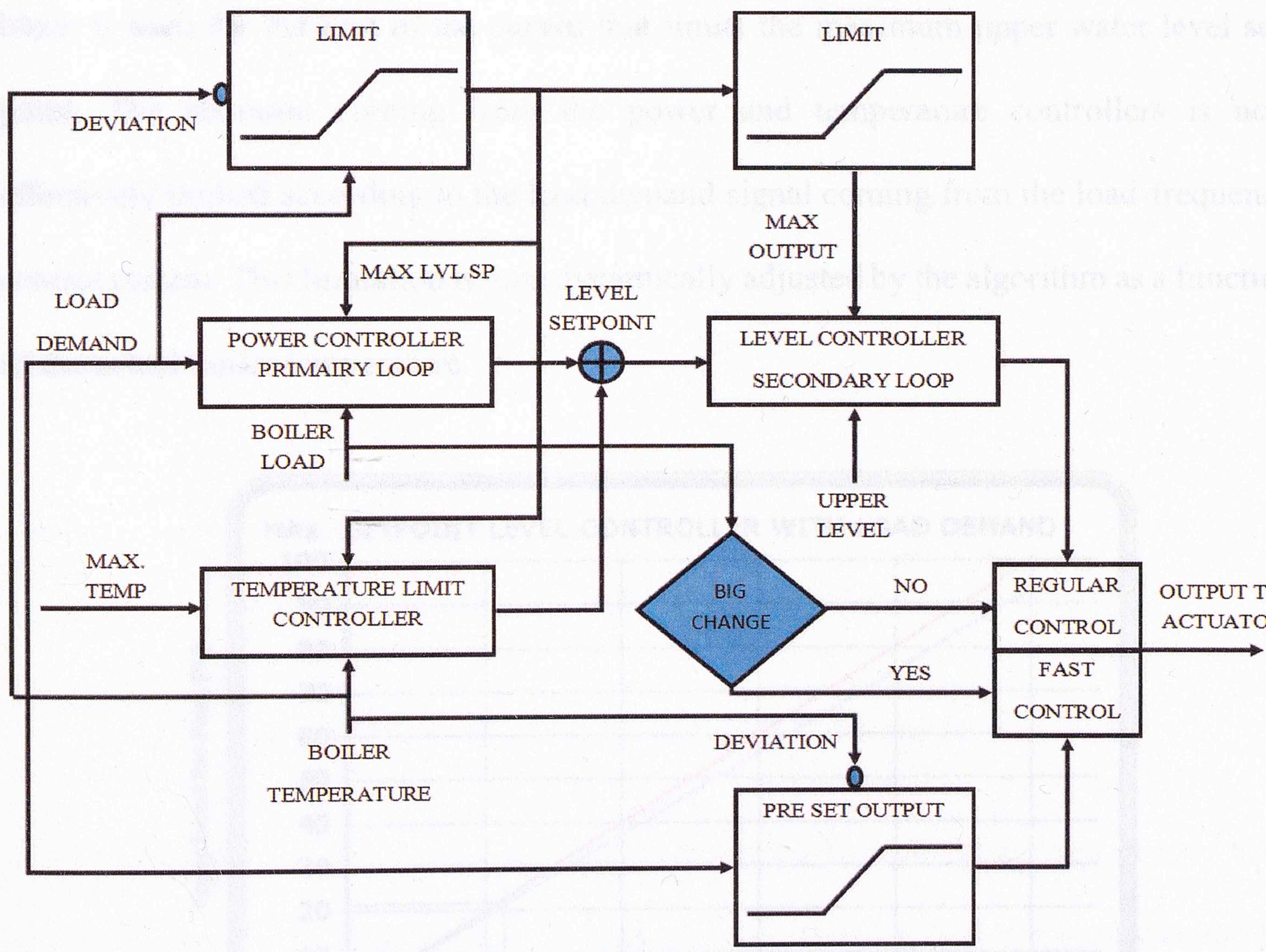

Figure 18 Control Flow PLC Program

The most significant improvement consists of temperature compensation in the curve function block. By calculating the deviation in conductivity, caused by the change in temperature, and input this deviation as a percentage in the function block, the output will be automatically adjusted. This adjustment is also dynamically made visible in the Human Machine Interface (HMI) screen by adding an extra line to the XY-chart as shown in Figure 19. The red line depicts the original curve set at the lowest operational temperature. The blue line is the result of the original curve recalculated using the new algorithm and the current boiler temperature. The green line shows the current maximum upper water level set-point with the external power controller set-point. The improved curve function block is used for the first of the curves that limits the maximum upper water level set-point. The set-point coming from the power and temperature controllers is now effectively limited according to the load demand signal coming from the load-frequency control system. This limitation is now dynamically adjusted by the algorithm as a function of the actual boiler temperature.

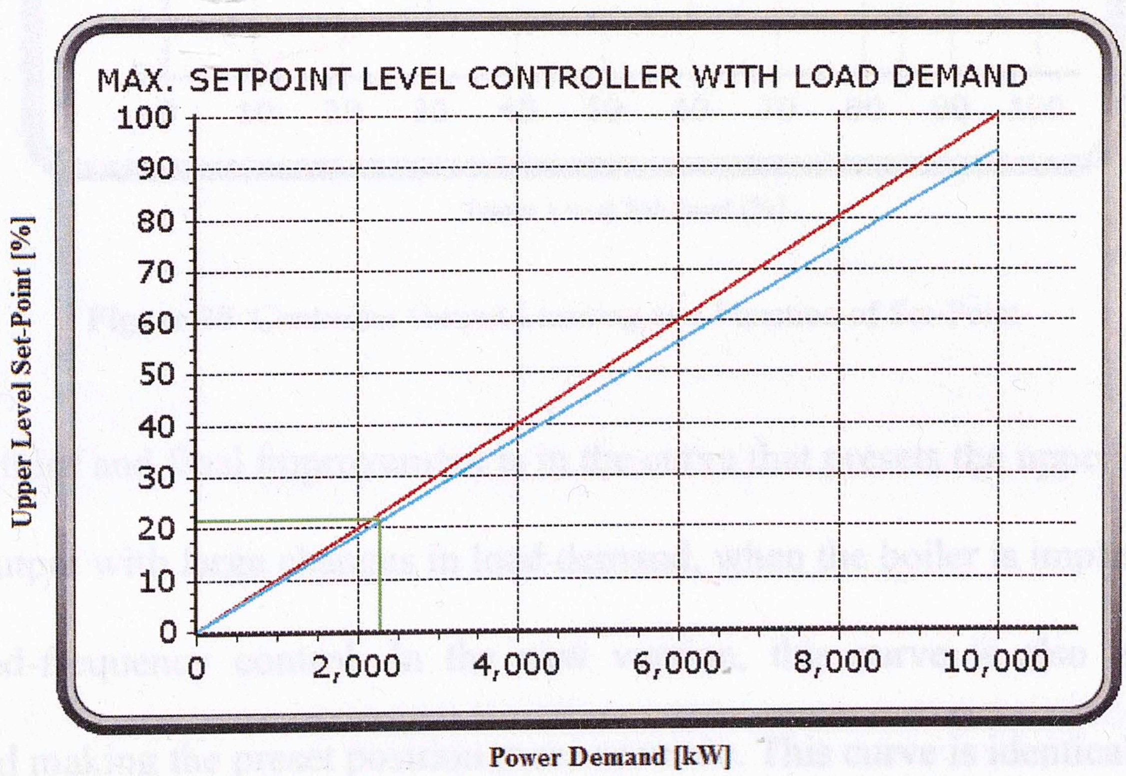

Figure 19 Improved XY-Curve Visualization

The second improvement is a simple control flow adjustment in the program. Instead of using the load demand signal to limit the output of the level controller, the actual level set-point limitation is used. This improves the accuracy of the system by effectively adjusting the maximum output of the level controller not only by the load demand, but also the maximum level set-point, which is now temperature compensated. In Figure 20 the improved XY-curve, the horizontal axis depicts the current maximum upper water level set-point.

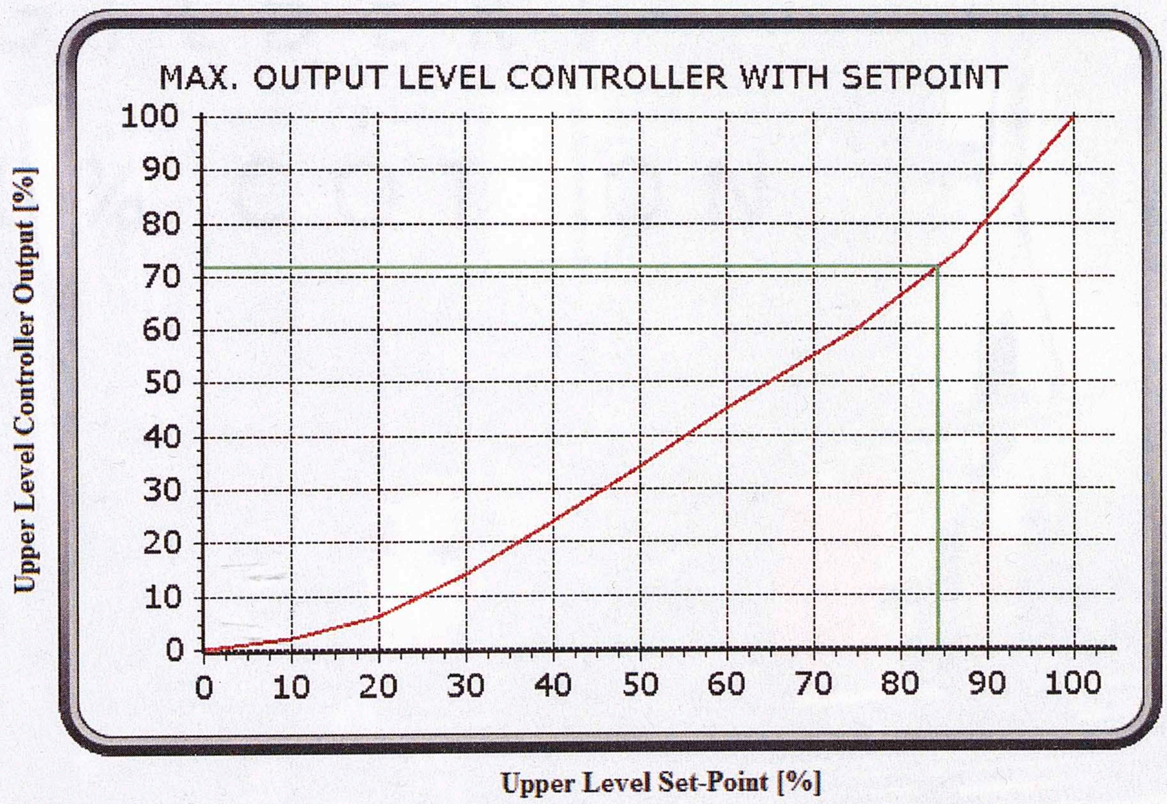

Figure 20 Controller Output Limiting as a Function of Set-Point

The third and final improvement is in the curve that presets the upper water level controller output with large changes in load demand, when the boiler is implemented for primary load-frequency control. In the new version, this curve is also temperature compensated making the preset position more accurate. This curve is identical to the one depicted in Figure 19.

Chapter 5: Results and Discussion

Validation of the improved algorithm was performed in cooperation with AS Scan and Hvide Sande Fjernvarme A.m.b.A. The installation is shown in Figure 21. The PARAT IEH in Hvide Sande was the first of a series of electrode boilers deployed in Denmark. The boiler has been in continuous operation since 2010. The boiler is rated at 10 MW but is only approved for operation up to 6 MW due to problems in the electrical supply grid. During initial commissioning, the low load limit was fixed at 400 kW.

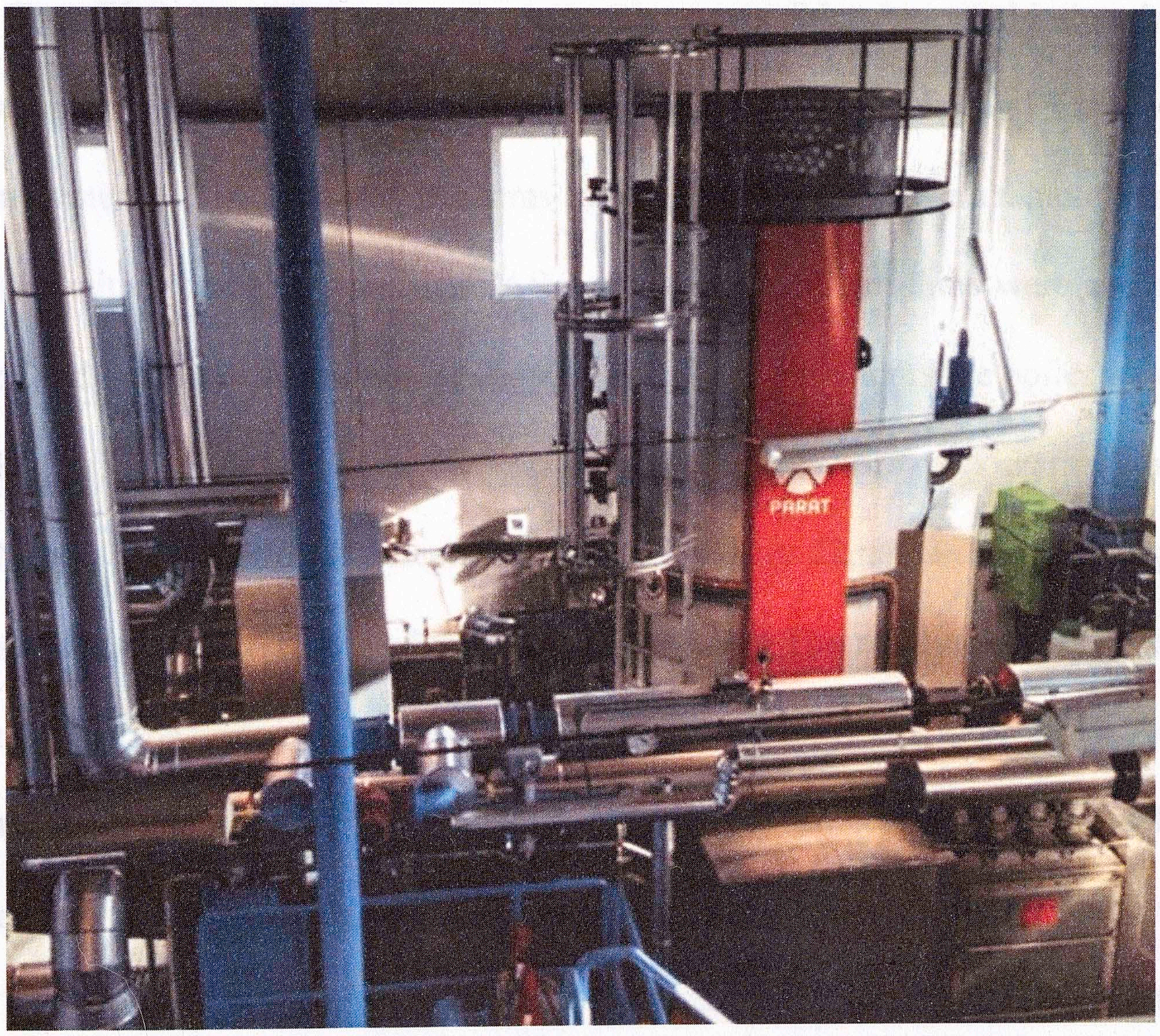

Figure 21 PARAT IEH in Hvide Sande Denmark

In 2013 AS Scan proposed a change to the shape of the center rod in the electrodes. The proposed change was to elongate the spherical tip of the center rod to a cone shape. The elongated shape resulted in a smaller contact area with the water during low loads allowing for even lower loads. The new electrode shape was successfully implemented in various electrode boilers in Denmark and was recently installed in the PARAT IEH in Hvide Sande. Another mechanical improvement to decrease low loads was an added insulating layer of TEFLON® in the bottom of the inner container. This layer was added to increase the resistance between the electrodes, resulting in the ability to operate at lower loads.

The PLC control system is remotely accessible for troubleshooting and monitoring purposes. During the commissioning, after the mechanical improvements were implemented, the derived algorithms for the control system were remotely installed and tested with local assistance from AS Scan. After the algorithms were successfully installed and verified, the boiler was engaged and for several hours the boiler was cycled through a variety of loads to ensure correct operation in the entire working range between 100 kW to 6 MW. The HMI screen, as shown in Figure 22, shows the trending of the process values and set-points of the power controller. The red line depicts the actual electrical load consumed by the boiler, measured in the main circuit breaker. The green line is the set-point that is remotely set by the load-frequency control system and the final blue line is the output of the power controller that is used as the upper water level set-point. The first test was performed with the mechanical changes in place, but without activating the new algorithms. This provides the necessary data to set the XY-curves for the lower operating temperature range.

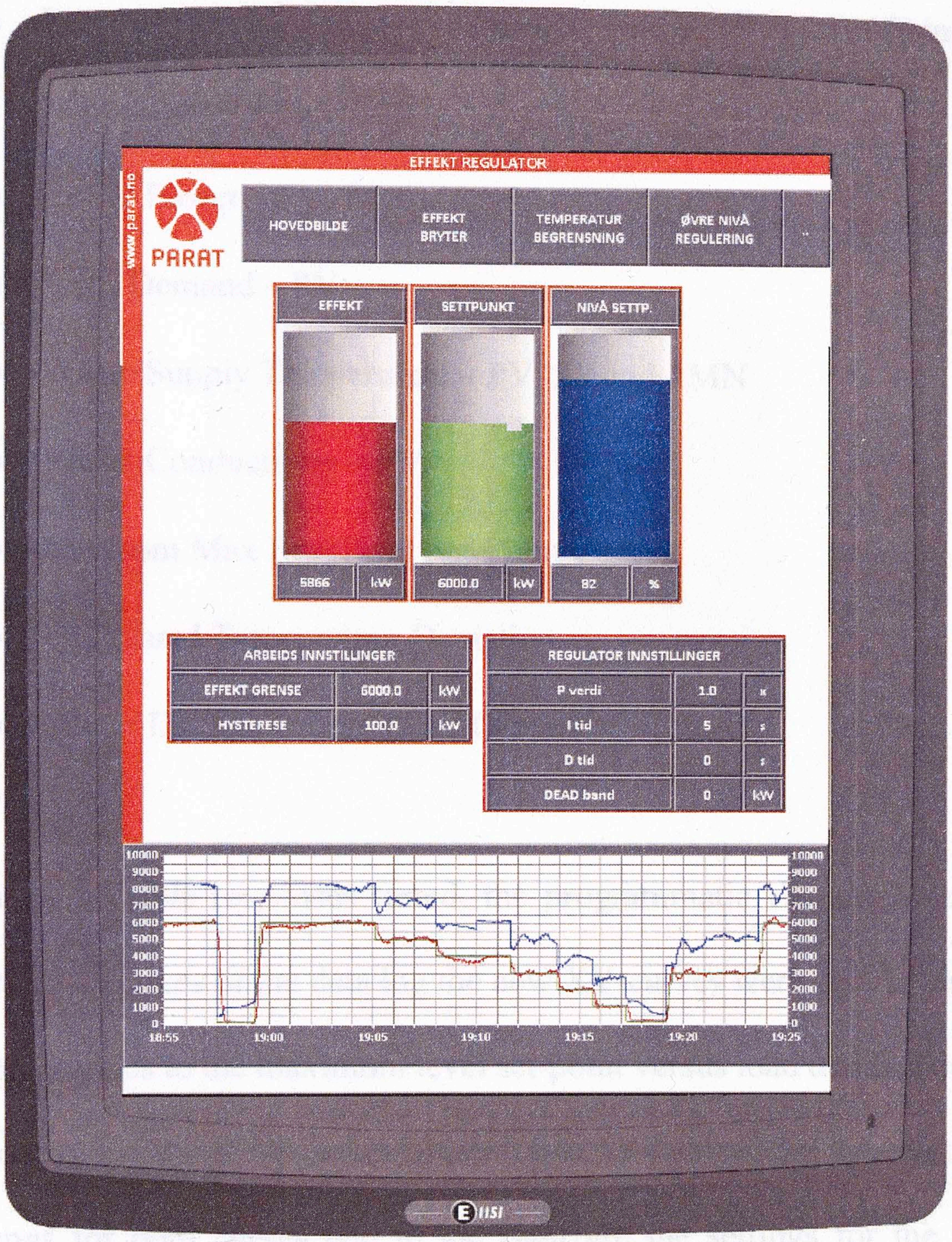

Figure 22 Power Controller

It can be seen in Figure 22 that the changes in temperature cause some volatile responses in the controller. To ensure all important process values were registered, an Object Linking and Embedded for Process Control (OPC) data logger was used to log several key parameters. A cycle time of 500 ms was used to log the data. An excerpt of the data log is shown in appendix D. Not all recorded parameters are included in appendix D to save space. The key parameters that were logged during testing were:

- Level Inner Container - Process Value (PV), Set-Point (SP) and Manipulated Value (LMN)
- Boiler Power – PV, SP and LMN
- Load Demand – PV
- Boiler Supply Temperature – PV, SP and LMN
- Boiler Conductivity – PV
- Out from Max Level and Set-Point Curves
- Calculated Temperature Deviation
- Power Deviation from Load Demand

With all possible responses tested, the programmatic changes were activated. Using the obtained values of the data log the new XY-curves were set. As can be seen in Figure 23, the changes to the maximum level set-point versus load demand curve and the maximum controller output versus maximum level set-point curve were set. To the left are the settings for both curves and to the right are the settings for the temperature deviation as determined from the calculations made in the previous sections and the actual temperature data from the log. The settings are accessible by the operator, but a password is needed to make any changes to the curves. This is to ensure the operator is aware of the possible severity of changes and prohibits non-authorized personnel from making changes.

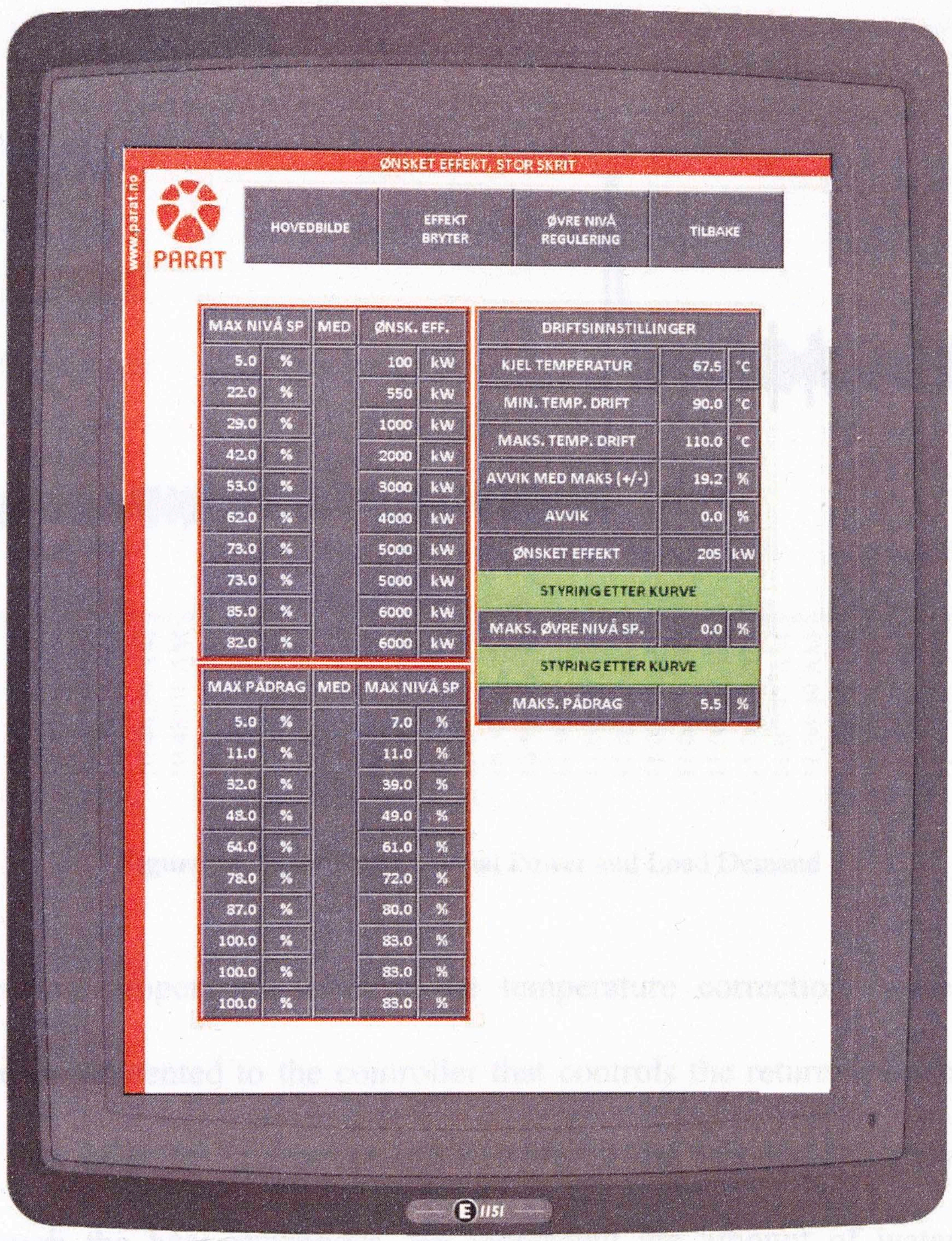

Figure 23 Maximum SP / Output Curves

Figure 24 shows a graph of the error between the actual absorbed power and the external load demand signal. The first half of the graph depicts operation without the improved XY-curves in active mode. The second half shows initial operation with the new algorithm dynamically adjusting the XY-curves. It can clearly be seen that there is a significant improvement in the accuracy of the controller.

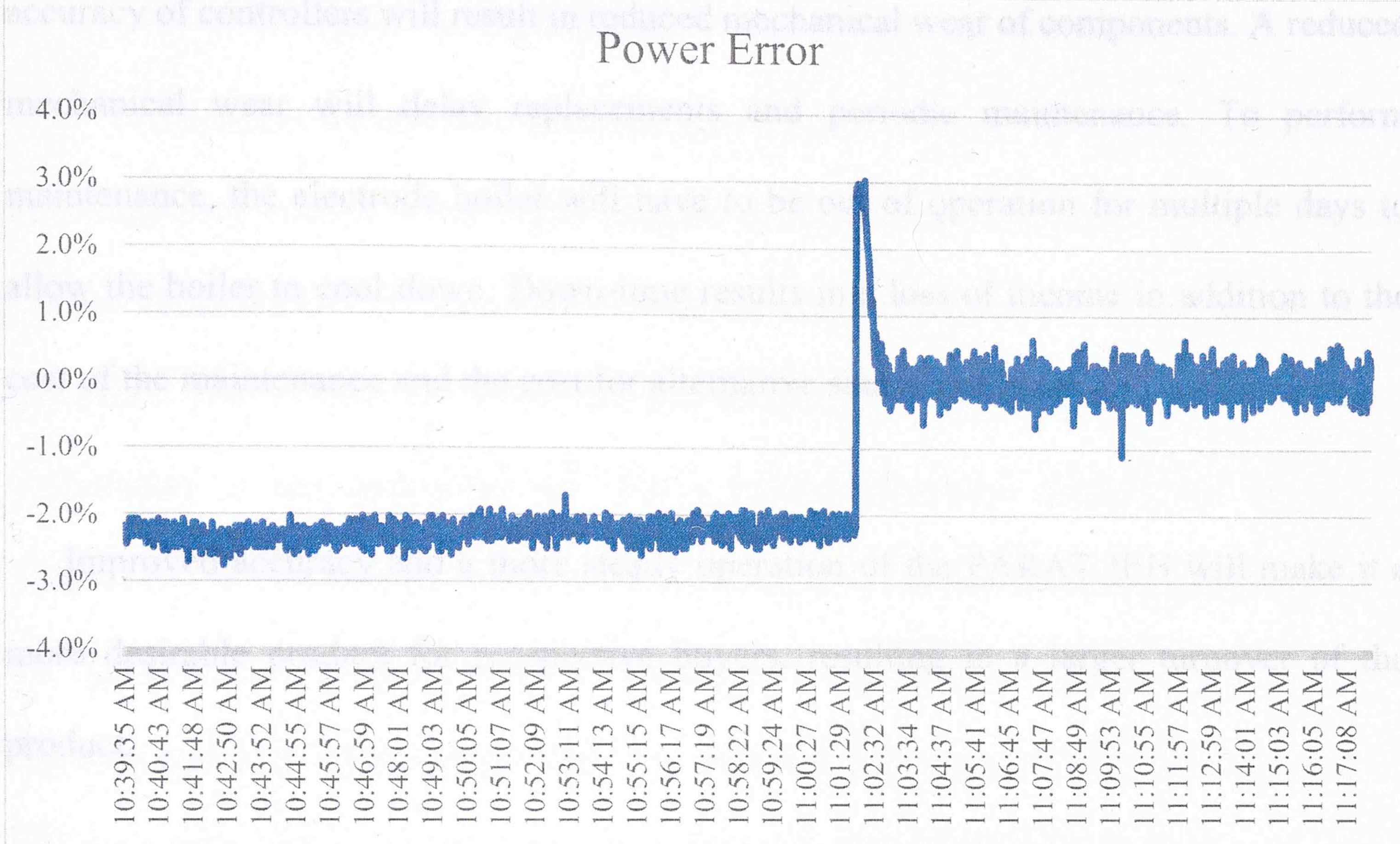

Figure 24 Error Factor Actual Power and Load Demand

To ensure proper operation of the temperature correction, some additional changes were implemented to the controller that controls the return temperature of the boiler. This was done by increasing and decreasing the amount of hot water that is pumped through the heat exchanger. By increasing the amount of water circulated through the heat-exchanger, consequently decreasing the amount of water that is bypassing the heat exchanger, the amount of energy that is delivered to the consumer distribution grid becomes much higher and the temperature out of the heat exchanger falls. The speed of this controller was increased, to ensure a more stable return temperature to the boiler.

The improvements in boiler accuracy will have no direct economic consequences, but over time can have significant indirect implications. Less volatility and improved accuracy of controllers will result in reduced mechanical wear of components. A reduced mechanical wear will delay replacements and periodic maintenance. To perform maintenance, the electrode boiler will have to be out of operation for multiple days to allow the boiler to cool down. Down-time results in a loss of income in addition to the cost of the maintenance and the cost for alternative sources of heat.

Improved accuracy and a more steady operation of the PARAT IEH will make it a more desirable product for prospective buyers, resulting in a larger turnover of the product.

Steady operation will result in a better load-frequency control of the electric grid, causing an overall improvement of power quality.

Chapter 6: Conclusions and Recommendations

This thesis successfully demonstrates a novel solution to improve accuracy of load-frequency control when high-voltage electrode boilers are used for this purpose. Current installations experience issues with the volatility and speed of the boiler power controller. This is partly due to the fact that the change in boiler water conductivity with temperature is not accounted for. For a typical hot-water boiler, the change in conductivity is almost 20%, which translates to a 15% increase in power consumption in the operational temperature range of the boiler. Normal boiler control is effected by a cascaded series of control-loops. The loop behavior is determined by a set of XY-curves that are determined during the initial commissioning of a boiler installation.

A new algorithm was developed that dynamically modifies the slope of certain XY-curves to account for changes in conductivity with changes of temperature. The algorithm was implemented and tested in an active installation situated in Hvide Sande, Denmark. Test results indicated that the mean power error, the difference between actual power and power set-point, was reduced to near 0% after implementing the algorithm. This provides a more accurate control when using a high-voltage electrode boiler for primary load-frequency control. The increasing number, and electrical capacity, of wind turbines, combined with the reduction of traditional power production facilities, causes greater volatility in electrical grid frequencies. This calls for a new and novel way of countering frequency deviations. High-voltage electrode boilers are a simple and inexpensive solution to this problem. The new control system, with improved accuracy enhances the desirability the high-voltage electrode boiler for implementation in load-frequency control.

The advantages of implementing a high-voltage electrode boiler in the utility grid are numerous and depend on the application. Regardless of the application, thanks to the relatively simple construction of the high-voltage electrode boiler, in the form of a PARAT IEH, it is possible to keep the physical size and the investment cost down. The simplicity makes it possible for the customer to perform basic maintenance without the need of external experts. It also offers a great back-up source of thermal energy if problems arise with the natural gas supply. No available gas means that neither combined heat and power (CHP) engines nor gas-fired boilers can be operated to ensure a steady source of heat. Feed-back from existing users, and information supplied at time of inquiry suggest a wide area of implementation. The first series of electrode boilers, installed in Denmark by PARAT Halvorsen AS, were implemented for primary load-frequency control of the local electrical grid. There are several advantages to implementing an electrode boiler for primary load-frequency control in comparison to using CHP engines, which is the commonly used method for this purpose. Most importantly, the guaranteed area of control, which is 2% to 100% of rated power, with the control speeds associated with this area (< 30 seconds), offer a major advantage. CHP engines have greatest efficiency at 75% to 90% of the rated load with similar control speeds; the lowest recommended load is about 20%. Secondary load-frequency control does not rely on the fast control speeds, but does take advantage of the large area of control.

Another potential area of use is to convert excess wind-generated electrical energy to thermal energy. The major problem associated with wind-generated power is the uncertainty in availability of wind. This can be partially countered by lowering the generating capacity of the wind-turbines such that the availability of this capacity can be guaranteed for extended periods. The lowering of the generating capacity consequently means that potential wind-power that could be converted to electrical energy is not fully utilized. If all available wind were to be converted to electrical energy, a fast acting electrode boiler could be utilized to convert excess energy to thermal energy when available. Industrial processes could easily use this thermal energy.

A recommended future research opportunity is to perform a feasibility study for the implementation of high-voltage electrode boilers for load-frequency control in the United States. The main issue will be to find a suitable thermal energy consumer. Several larger cities like New York and San Francisco have extended district heating and a non-polluting source of heat as a by-product from load-frequency control might be very attractive. With the ever-increasing foot-print of bigger cities, the necessity of decentralized generation becomes a feasible opportunity. Problems with load-frequency control that may arise from decentralized generation, may be mitigated by implementing high-voltage electrode boilers.

An additional topic that has immersive research opportunities is thermoelectric generation; for example, using high-voltage electrode boilers to generate thermal energy from excess electrical energy, generated by wind-turbines. This thermal energy can easily be stored in massive accumulation tanks in the form of water or other materials that have good thermal properties, like molten salt. The problem that is encountered is the temperature range. A typical PARAT IEH high-voltage electrode boiler can produce water of about 230 °C, at a pressure of 30 bar, but additional overheating of the steam is necessary to make it suitable for electricity generation by steam turbines.

The successful implementation of the algorithm presented in this thesis provides a fundamental building block toward expanded use of high-voltage electrode boilers for load-frequency control with the added benefit of thermal energy as a by-product for use by various consumers. The enhanced control algorithm is particularly relevant in applications with increased volatility due to electrical power production by wind-turbines.

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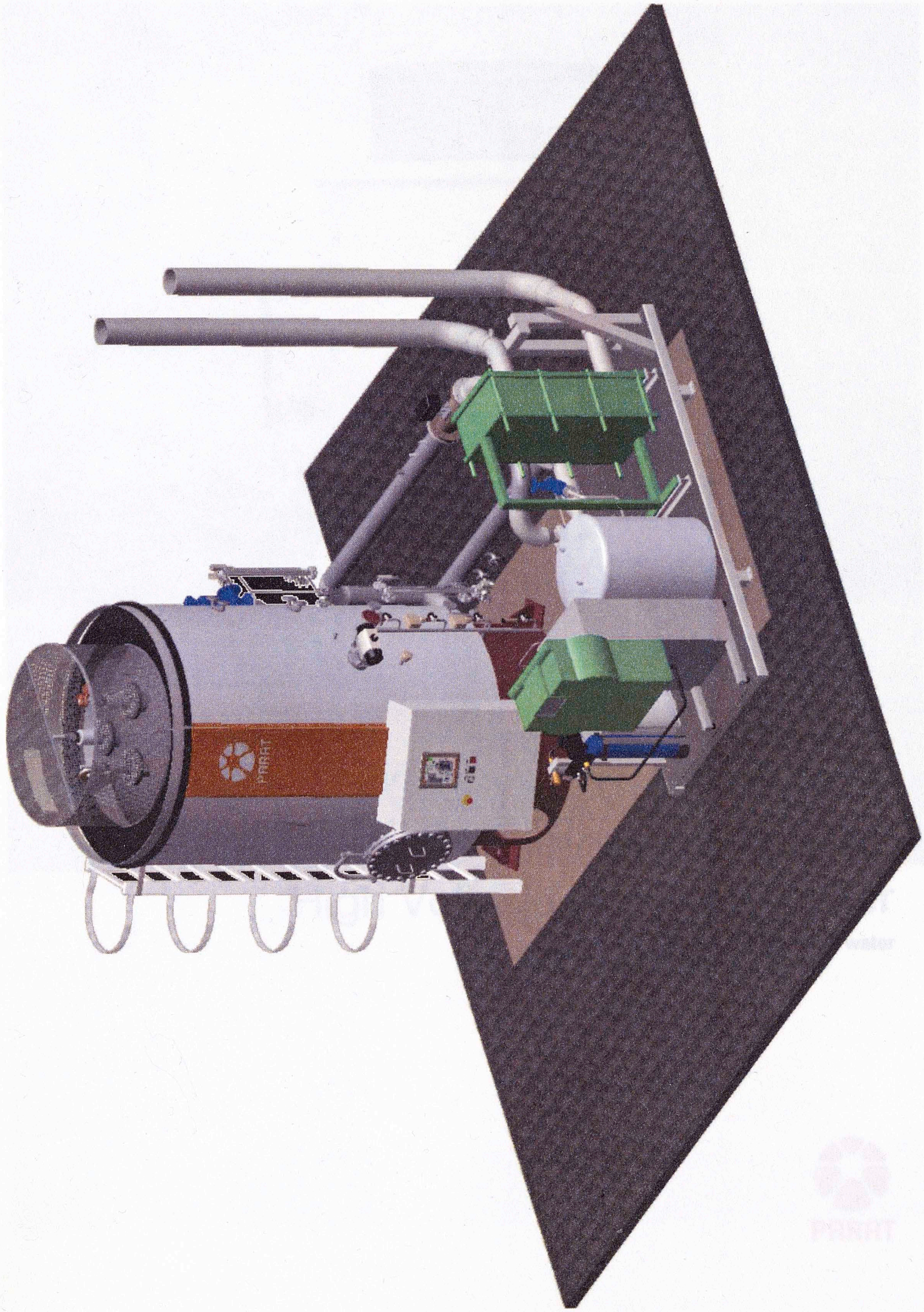
Appendix A: PARAT IEH Typical Arrangement



Appendix B: PARAT IEH Product Sheet

High Voltage Electrode Boiler

Steam and Hot water

PARAT

From renewable POWER to HEAT with PARAT electrode boiler

From minimum to full load in under 30 seconds.

PARAT; boilers since 1920

Our electrode boiler has been designed and developed by our in-house engineers and manufactured in our workshop in Norway for more than 20 years.

Our boiler history goes all the way back to 1920. Since we started we have delivered more than 7000 boilers to the Norwegian market alone. Today we are the largest supplier of boiler systems in Norway.

Electrical grid regulation

Increasing power generation from wind and solar systems have created a demand for fast frequency regulation of the electrical power grids. The PARAT electrode boiler can be used for primary regulation with less than 30 seconds response time from minimum to full load.

Converting electrical power to heat makes it possible to accumulate renewable energy in periods of overproduction. Our partner AS:SCAN in Denmark has installed more than 7 PARAT electrode boilers in the Danish grid.

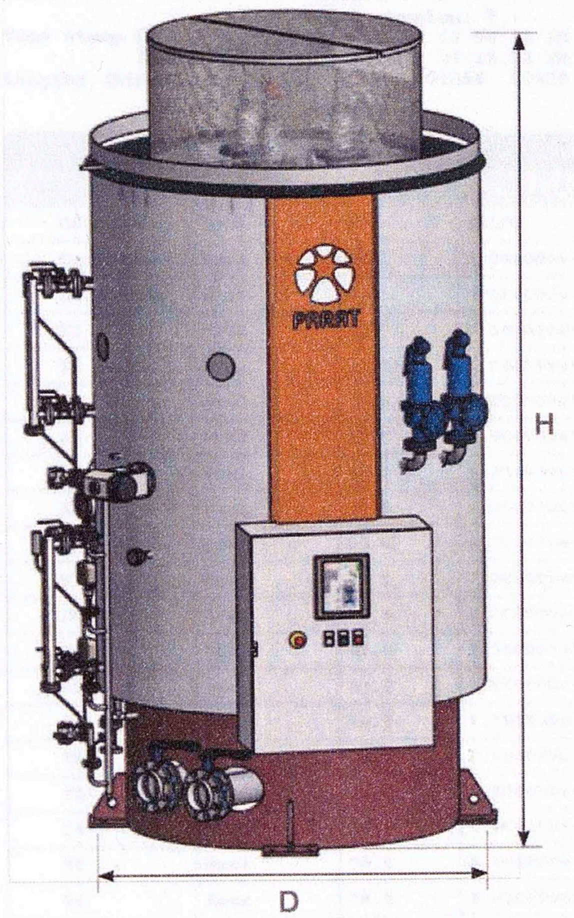
Steam and hot water

The electrode boiler is delivered both in a steam and hot water version with maximum pressure of 30 barg.

- From cold to full load in less than 15 minutes
- 30 seconds from minimum to full load
- Minimum load is below 2%
- No earth current
- Compact design - up to 50MW in one unit
- No low voltage transformer required
- No Electrode wear
- Minimum maintenance required

PARAT IEH: High Voltage Electrode Boiler

Technical data



Area of use:

- Steam and Hot water production when electricity is cheap
- Grid regulation
- Backup boiler with fast startup time
- Load balancing in gas turbine systems
- Extremely compact for large power loads

Design codes

We deliver the boiler CE marked according to PED/97/23/EC with boiler code EN12953 or ASME stamp. The IEH is also available in EX version for installation in zone 2 hazardous areas.

Marine version available

PARAT has developed a patented system for marine installation and application. The PARAT electrode boiler is in full operation on the deck of the FPSO BW Pioneer in the US Gulf of Mexico.

Control system

We have used our experience to develope a modern and robust boiler control system which is easy to use. The boiler is also available with PARAT remote monitoring system. This enables web-based remote monitoring of the boiler plant from anywhere in the world. This also includes online troubleshooting and upgrades of the control software from the PARAT Halvorsen AS service centre in Norway.

Capacity (MW)	0-10	11-15	16-20	21-30	31-45
Capacity (T/h)	0-15	16-22,5	23-30	31-45	46-67
D (mm)	2100	2100	2550	3000	3400
H (mm)	5099	5099	5255	5635	6000
Transport weight (kg)	4500	5000	6500	7000	14000
Operating weight (kg)	7000	7500	10500	14000	23000
Test weight (kg)	12000	12500	19000	27000	44000

Boiler outer dimensions including insulation mantle. Design pressure 16 barg.
We reserve the right to make changes.

Dovre Sertifisering AS

NS-EN ISO 9001 CERTIFIED COMPANY

PARAT

www.parat.no

Parat Halvorsen AS P.O. Box 173 NO-4402 Flekkefjord Norway
Tel +47 99 48 55 00 Fax +47 38 32 44 71 office@parat.no

Appendix C: Program Code

FB44 - <offline>
"Curve FB"
Name: **Family:**
Author: **Version:** 0.1
Block version: 2
Time stamp Code: 03/17/2014 02:54:54 PM
Interface: 03/15/2014 04:28:33 PM
Lengths (block/logic/data): 01392 01088 00000

Name	Data Type	Address	Initial Value	Comment
IN		0.0		
Curve_On	Bool	0.0	FALSE	
Controller	Real	2.0	0.000000e+000	
Deviation	Real	6.0	0.000000e+000	-100.0..100.0 [%]
X0	Real	10.0	0.000000e+000	
X1	Real	14.0	1.000000e+001	
X2	Real	18.0	2.000000e+001	
X3	Real	22.0	3.000000e+001	
X4	Real	26.0	4.000000e+001	
X5	Real	30.0	5.000000e+001	
X6	Real	34.0	6.000000e+001	
X7	Real	38.0	7.000000e+001	
X8	Real	42.0	8.000000e+001	
X9	Real	46.0	9.000000e+001	
Y0	Real	50.0	0.000000e+000	
Y1	Real	54.0	1.000000e+001	
Y2	Real	58.0	2.000000e+001	
Y3	Real	62.0	3.000000e+001	
Y4	Real	66.0	4.000000e+001	
Y5	Real	70.0	5.000000e+001	
Y6	Real	74.0	6.000000e+001	
Y7	Real	78.0	7.000000e+001	
Y8	Real	82.0	8.000000e+001	
Y9	Real	86.0	9.000000e+001	
OUT		0.0		
Setpoint	Real	90.0	0.000000e+000	
Y00	Real	94.0	0.000000e+000	
Y01	Real	98.0	0.000000e+000	
Y02	Real	102.0	0.000000e+000	
X00	Real	106.0	0.000000e+000	
X01	Real	110.0	0.000000e+000	
X02	Real	114.0	0.000000e+000	
IN_OUT		0.0		
STAT		0.0		
DiffX	Real	118.0	0.000000e+000	
DiffY	Real	122.0	0.000000e+000	
YbyX	Real	126.0	0.000000e+000	
Output	Real	130.0	0.000000e+000	
Dev_Factor	Real	134.0	0.000000e+000	

Name	Data Type	Address	Initial Value	Comment
Y0_dev	Real	138.0	0.000000e+000	
Y1_dev	Real	142.0	0.000000e+000	
Y2_dev	Real	146.0	0.000000e+000	
Y3_dev	Real	150.0	0.000000e+000	
Y4_dev	Real	154.0	0.000000e+000	
Y5_dev	Real	158.0	0.000000e+000	
Y6_dev	Real	162.0	0.000000e+000	
Y7_dev	Real	166.0	0.000000e+000	
Y8_dev	Real	170.0	8.000000e+001	
Y9_dev	Real	174.0	0.000000e+000	
TEMP		0.0		

Block: FB44

Network: 1

Determine deviation factor and construct setpoint line, actual factor is being set from outside function block

```
L     #Deviation       //load deviation in percent       #Deviation       -- -100.0..100.0 [%]
L     1.000000e+002
+R
L     1.000000e+002
/R
T     #Dev_Factor      //convert in factor               #Dev_Factor
L     #Y0              //calculate new Y values          #Y0
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y0_dev                                            #Y0_dev
L     #Y1                                                #Y1
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y1_dev                                            #Y1_dev
L     #Y2                                                #Y2
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y2_dev                                            #Y2_dev
L     #Y3                                                #Y3
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y3_dev                                            #Y3_dev
L     #Y4                                                #Y4
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y4_dev                                            #Y4_dev
L     #Y5                                                #Y5
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y5_dev                                            #Y5_dev
L     #Y6                                                #Y6
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y6_dev                                            #Y6_dev
L     #Y7                                                #Y7
L     #Dev_Factor                                        #Dev_Factor
*R
T     #Y7_dev                                            #Y7_dev
```

```
      L     #Y8                                                       #Y8
      L     #Dev_Factor                                               #Dev_Factor
      *R
      T     #Y8_dev                                                   #Y8_dev

      L     #Y9                                                       #Y9
      L     #Dev_Factor                                               #Dev_Factor
      *R
      T     #Y9_dev                                                   #Y9_dev
```

Network: 2

```
      A     #Curve_On     //if curve is inactive, jump to last stateme  #Curve_On
                          nt
      JNB   END
      L     #X0           //compare lowest value to controller          #X0
      L     #Controller                                                 #Controller
      >=R
      JCN   JX0           //if controller is higher than X0 jump to next part
      L     #Y0           //if lower, move lowest Y to output           #Y0
      T     #Setpoint                                                   #Setpoint
      JU    END           //jump to last statement
JX0:  L     #X1           //if controller is higher than X1 jump to ne  #X1
                          xt part
      L     #Controller                                                 #Controller
      >=R
      JCN   JX1           //if lower, calculate difference between X1 and X0
      L     #X1                                                         #X1
      L     #X0                                                         #X0
      -R
      T     #DiffX                                                      #DiffX
      L     #Y1_dev       //calculate difference between Y1 and Y0      #Y1_dev
      L     #Y0_dev                                                     #Y0_dev
      -R
      T     #DiffY        //calculate difference Y per X                #DiffY
      L     #DiffX                                                      #DiffX
      /R
      T     #YbyX                                                       #YbyX
      L     #X0                                                         #X0
      L     #Controller                                                 #Controller
      TAK
      -R
      L     #YbyX                                                       #YbyX
      *R
      T     #Output       //calculate where on X line controller is     #Output
      L     #Y0_dev       //calculate what Y belongs to this position   #Y0_dev
      L     #Output                                                     #Output
      +R
      T     #Setpoint                                                   #Setpoint
      JU    END
JX1:  L     #X2           //as previous...                              #X2
      L     #Controller                                                 #Controller
      >=R
      JCN   JX2
      L     #X2                                                         #X2
      L     #X1                                                         #X1
      -R
      T     #DiffX                                                      #DiffX
      L     #Y2_dev                                                     #Y2_dev
      L     #Y1_dev                                                     #Y1_dev
      -R
      T     #DiffY                                                      #DiffY
      L     #DiffX                                                      #DiffX
      /R
      T     #YbyX                                                       #YbyX
      L     #X1                                                         #X1
      L     #Controller                                                 #Controller
      TAK
      -R
      L     #YbyX                                                       #YbyX
```

```
      *R
      T     #Output                                     #Output
      L     #Y1_dev                                     #Y1_dev
      L     #Output                                     #Output
      +R
      T     #Setpoint                                   #Setpoint
      JU    END
JX2:  L     #X3                                         #X3
      L     #Controller                                 #Controller
      >=R
      JCN   JX3
      L     #X3                                         #X3
      L     #X2                                         #X2
      -R
      T     #DiffX                                      #DiffX
      L     #Y3_dev                                     #Y3_dev
      L     #Y2_dev                                     #Y2_dev
      -R
      T     #DiffY                                      #DiffY
      L     #DiffX                                      #DiffX
      /R
      T     #YbyX                                       #YbyX
      L     #X2                                         #X2
      L     #Controller                                 #Controller
      TAK
      -R
      L     #YbyX                                       #YbyX
      *R
      T     #Output                                     #Output
      L     #Y2_dev                                     #Y2_dev
      L     #Output                                     #Output
      +R
      T     #Setpoint                                   #Setpoint

      JU    END
JX3:  L     #X4                                         #X4
      L     #Controller                                 #Controller
      >=R
      JCN   JX4
      L     #X4                                         #X4
      L     #X3                                         #X3
      -R
      T     #DiffX                                      #DiffX
      L     #Y4_dev                                     #Y4_dev
      L     #Y3_dev                                     #Y3_dev
      -R
      T     #DiffY                                      #DiffY
      L     #DiffX                                      #DiffX
      /R
      T     #YbyX                                       #YbyX
      L     #X3                                         #X3
      L     #Controller                                 #Controller
      TAK
      -R
      L     #YbyX                                       #YbyX
      *R
      T     #Output                                     #Output
      L     #Y3_dev                                     #Y3_dev
      L     #Output                                     #Output
      +R
      T     #Setpoint                                   #Setpoint
      JU    END
JX4:  L     #X5                                         #X5
      L     #Controller                                 #Controller
      >=R
      JCN   JX5
      L     #X5                                         #X5
      L     #X4                                         #X4
      -R
      T     #DiffX                                      #DiffX
      L     #Y5_dev                                     #Y5_dev
      L     #Y4_dev                                     #Y4_dev
      -R
      T     #DiffY                                      #DiffY
      L     #DiffX                                      #DiffX
```

```
      /R
      T     #YbyK                                  #YbyK
      L     #X4                                    #X4
      L     #Controller                            #Controller
      TAK
      -R
      L     #YbyK                                  #YbyK
      *R
      T     #Output                                #Output
      L     #Y4_dev                                #Y4_dev
      L     #Output                                #Output
      +R
      T     #Setpoint                              #Setpoint
      JU    END
JX5:  L     #X6                                    #X6
      L     #Controller                            #Controller
      >=R
      JCN   JX6
      L     #X6                                    #X6
      L     #X5                                    #X5
      -R
      T     #DiffX                                 #DiffX
      L     #Y6_dev                                #Y6_dev
      L     #Y5_dev                                #Y5_dev
      -R
      T     #DiffY                                 #DiffY
      L     #DiffX                                 #DiffX
      /R
      T     #YbyK                                  #YbyK
      L     #X5                                    #X5
      L     #Controller                            #Controller
      TAK
      -R
      L     #YbyK                                  #YbyK
      *R
      T     #Output                                #Output
      L     #Y5_dev                                #Y5_dev
      L     #Output                                #Output
      +R
      T     #Setpoint                              #Setpoint
      JU    END
JX6:  L     #X7                                    #X7
      L     #Controller                            #Controller
      >=R
      JCN   JX7
      L     #X7                                    #X7
      L     #X6                                    #X6
      -R
      T     #DiffX                                 #DiffX
      L     #Y7_dev                                #Y7_dev
      L     #Y6_dev                                #Y6_dev
      -R
      T     #DiffY                                 #DiffY
      L     #DiffX                                 #DiffX
      /R
      T     #YbyK                                  #YbyK
      L     #X6                                    #X6
      L     #Controller                            #Controller
      TAK
      -R
      L     #YbyK                                  #YbyK
      *R
      T     #Output                                #Output
      L     #Y6_dev                                #Y6_dev
      L     #Output                                #Output
      +R
      T     #Setpoint                              #Setpoint
      JU    END
JX7:  L     #X8                                    #X8
      L     #Controller                            #Controller
      >=R
      JCN   JX8
      L     #X8                                    #X8
      L     #X7                                    #X7
      -R
```

```
      T     #DiffX                                                      #DiffX
      L     #Y8_dev                                                     #Y8_dev
      L     #Y7_dev                                                     #Y7_dev
      -R
      T     #DiffY                                                      #DiffY
      L     #DiffX                                                      #DiffX
      /R
      T     #YbyX                                                       #YbyX
      L     #X7                                                         #X7
      L     #Controller                                                 #Controller
      TAK
      -R
      L     #YbyX                                                       #YbyX
      *R
      T     #Output                                                     #Output
      L     #Y7                                                         #Y7
      L     #Output                                                     #Output
      +R
      T     #Setpoint                                                   #Setpoint
      JU    END
JX8:  L     #X9                                                         #X9
      L     #Controller                                                 #Controller
      >=R
      JCN   JX9
      L     #X9                                                         #X9
      L     #X8                                                         #X8
      -R
      T     #DiffX                                                      #DiffX
      L     #Y9_dev                                                     #Y9_dev
      L     #Y8_dev                                                     #Y8_dev
      -R
      T     #DiffY                                                      #DiffY
      L     #DiffX                                                      #DiffX
      /R
      T     #YbyX                                                       #YbyX
      L     #X8                                                         #X8
      L     #Controller                                                 #Controller
      TAK
      -R
      L     #YbyX                                                       #YbyX
      *R
      T     #Output                                                     #Output
      L     #Y8_dev                                                     #Y8_dev
      L     #Output                                                     #Output
      +R
      T     #Setpoint                                                   #Setpoint
      JU    END

JX9:  L     #X9            //compare controller to highest X value      #X9
      L     #Controller    //if higher mover highest Y to output        #Controller
      >=R
      L     #Y9_dev                                                     #Y9_dev
      T     #Setpoint                                                   #Setpoint

END:  L     #Controller    //calculte X-Y coordinates for pointing line #Controller
                           s in curve
      T     #X01                                                        #X01
      T     #X02                                                        #X02
      L     #X0                                                         #X0
      T     #X00                                                        #X00
      L     0.000000e+000
      T     #Y02                                                        #Y02

      L     #Setpoint                                                   #Setpoint
      T     #Y00                                                        #Y00
      T     #Y01                                                        #Y01
```

Appendix D: Excerpt from Process Data

Timestamp	Calc. Deviation [%]	Cond. PV [µS]	Load Dem. PV [*100kW]	Power PV [*100kW]	Power SP [*100kW]	Power LMN [%]	Temp. PV [°C]	LVL Upper PV [%]	LVL Upper SP [%]	LVL Upper LMN [%]	Max Output [%]	Max SP [%]
10:39:43 AM	0	63.77315	5	3.596643	2.120003	10	83.46354	12.73148	10	2	8.653846	20
10:39:53 AM	0	63.42593	5	3.501158	2.153754	10	83.68056	12.73148	10	2	8.653846	20
10:40:08 AM	0	63.0787	5	3.564815	2.202505	10	84.02778	12.78935	10	2	8.653846	20
10:40:19 AM	0	63.19444	5	3.501158	2.236255	10	84.28819	12.67361	10	2	8.653846	20
10:40:29 AM	0	63.42593	5	3.628472	2.266256	10	84.50521	12.67361	10	2	8.653846	20
10:40:39 AM	0	63.0787	5	3.660301	2.296257	10	84.72222	12.67361	10	2	8.653846	20
10:40:50 AM	0	63.77315	5	3.501158	2.333758	10	84.98264	12.67361	10	2	8.653846	20
10:41:01 AM	0	63.77315	5	3.564815	2.367508	10	85.24305	12.61574	10	2	8.653846	20
10:41:11 AM	0	63.77315	5	3.564815	2.397509	10	85.46007	12.55787	10	2	8.653846	20
10:41:21 AM	0	63.42593	5	3.501158	2.42751	10	85.72048	12.55787	10	2	8.653846	20
10:41:31 AM	0	63.88889	5	3.564815	2.461261	10	85.9375	12.5	10	2	8.653846	20
10:41:42 AM	0	63.77315	5	3.628472	2.495011	10	86.19792	12.5	10	2	8.653846	20
10:41:52 AM	0	63.65741	5	3.564815	2.528762	10	86.37153	12.44213	10	2	8.653846	20
10:42:02 AM	0	63.77315	5	3.532986	2.558763	10	86.58854	12.38426	10	2	8.653846	20
10:42:12 AM	0	63.77315	5	3.469329	2.588763	10	86.80556	12.38426	10	2	8.653846	20
10:42:22 AM	0	63.77315	5	3.660301	2.622514	10	87.02258	12.21065	10	2	8.653846	20
10:42:32 AM	0	63.42593	5	3.692129	2.652515	10	87.23958	12.32639	10	2	8.653846	20
10:42:42 AM	0	63.19444	5	3.564815	2.682516	10	87.4566	12.21065	10	2	8.653846	20
10:42:52 AM	0	62.03704	5	3.596643	2.712516	10	87.67361	12.21065	10	2	8.653846	20
10:43:02 AM	0	60.99537	5	3.501158	2.742517	10	87.84722	12.15278	10	2	8.653846	20
10:43:12 AM	0	59.72222	5	3.4375	2.776268	10	88.06423	12.15278	10	2	8.653846	20
10:43:22 AM	0	59.14352	5	3.532986	2.806268	10	88.32465	12.15278	10	2	8.653846	20
10:43:32 AM	0	57.06019	5	3.310185	2.836269	10	88.54167	12.21065	10	2	8.653846	20
10:43:42 AM	0	59.83796	5	3.310185	2.87002	10	88.80209	12.21065	10	2	8.653846	20
10:43:52 AM	0	59.60648	5	3.278357	2.900021	10	88.93229	12.26852	10	2	8.653846	20
10:44:02 AM	0	60.18519	5	3.214699	2.930021	10	88.97569	12.38426	10	2	8.653846	20
10:44:13 AM	0	59.49074	5	3.373843	2.967522	10	89.0191	12.38426	10	2	8.653846	20
10:44:23 AM	0	61.34259	5	3.18287	2.997523	10	88.97569	12.44213	10	2	8.653846	20
10:44:33 AM	0	60.06944	5	3.405671	3.031274	10	88.80209	12.5	10	2	8.653846	20
10:44:43 AM	0	61.9213	5	3.246528	3.061274	10	88.71528	12.5	10	2	8.653846	20
10:44:53 AM	0	60.99537	5	3.246528	3.091275	10	88.45486	12.44213	10	2	8.653846	20
10:45:03 AM	0	62.15278	5	3.214699	3.121276	10	88.23785	12.44213	10	2	8.653846	20
10:45:13 AM	0	62.03704	5	3.405671	3.155026	10	88.02084	12.67361	10	2	8.653846	20
10:45:23 AM	0	61.80556	5	3.278357	3.185027	10	87.71702	12.55787	10	2	8.653846	20
10:45:33 AM	0	60.64815	5	3.246528	3.215028	10	87.4566	12.5	10	2	8.653846	20
10:45:43 AM	0	62.38426	5	3.278357	3.248779	10	87.15278	12.5	10	2	8.653846	20
10:45:53 AM	0	61.9213	5	3.310185	3.278779	10	86.93577	12.55787	10	2	8.653846	20
10:46:03 AM	0	63.65741	5	3.469329	3.30878	10	86.63194	12.5	10	2	8.653846	20
10:46:13 AM	0	62.15278	5	3.278357	3.342531	10	86.41492	12.44213	10	2	8.653846	20
10:46:23 AM	0	61.34259	5	3.278357	3.372531	10	86.15451	12.5	10	2	8.653846	20
10:46:33 AM	0	63.19444	5	3.373843	3.406282	10	85.8941	12.44213	10	2	8.653846	20
10:46:43 AM	0	63.19444	5	3.4375	3.436283	10	85.76389	12.55787	10	2	8.653846	20
10:46:53 AM	0	62.96296	5	3.405671	3.466284	10	85.63368	12.5	10	2	8.653846	20
10:47:03 AM	0	63.19444	5	3.4375	3.496284	10	85.46007	12.5	10	2	8.653846	20
10:47:13 AM	0	62.84722	5	3.4375	3.526285	10	85.37327	12.38426	10	2	8.653846	20
10:47:23 AM	0	62.73148	5	3.4375	3.560036	10	85.24305	12.38426	10	2	8.653846	20
10:47:33 AM	0	62.73148	5	3.373843	3.590036	10	85.15625	12.38426	10	2	8.653846	20
10:47:43 AM	0	62.26852	5	3.532986	3.623787	10.00335	85.15625	12.38426	10.00154	2	8.653846	20
10:47:53 AM	0	62.61574	5	3.342014	3.653788	10.72826	85.15625	12.44213	10.72203	2	8.653846	20
10:48:03 AM	0	61.57407	5	3.373843	3.687539	11.1976	85.15625	12.44213	11.18761	2.001735	8.653846	20
10:48:13 AM	0	61.9213	5	3.564815	3.717539	11.51152	85.15625	12.38426	11.56344	2	8.653846	20
10:48:23 AM	0	62.15278	5	3.310185	3.74754	12.44122	85.24305	12.44213	12.43247	2.162404	8.653846	20
10:48:33 AM	0	61.9213	5	3.405671	3.777541	13.05798	85.24305	12.44213	13.05055	2.240922	8.653846	20
10:48:43 AM	0	61.9213	5	3.532986	3.811291	13.68994	85.32986	12.44213	13.68066	3.180551	8.653846	20
10:48:53 AM	0	62.03704	5	3.214699	3.841292	14.95001	85.32986	12.44213	14.93748	5.654068	8.653846	20
10:49:03 AM	0	62.96296	5	3.596643	3.871293	15.36324	85.46007	12.38426	15.35774	8.484858	8.653846	20
10:49:13 AM	0	62.03704	5	3.469329	3.901294	16.42182	85.50347	12.32639	16.41318	8.653846	8.653846	20
10:49:23 AM	0	62.5	5	3.405671	3.935044	17.48389	85.54688	12.67361	17.4733	8.653846	8.653846	20
10:49:33 AM	0	61.9213	5	3.723958	3.965045	17.85506	85.54688	13.65741	17.85024	8.653846	8.653846	20
10:49:43 AM	0	63.19444	5	3.91493	3.998796	18.16485	85.63368	14.17824	18.16317	8.653846	8.653846	20
10:49:53 AM	0	62.61574	5	3.946759	4.028795	18.41059	85.63368	14.23611	18.53499	8.653846	8.653846	20
10:50:03 AM	0	62.61574	5	3.978588	4.062543	18.59091	85.72048	14.6412	18.58923	8.653846	8.653846	20
10:50:13 AM	0	62.5	5	3.978588	4.092542	18.74515	85.67709	14.87269	18.74287	8.653846	8.653846	20
10:50:23 AM	0	62.61574	5	4.105903	4.122541	18.72623	85.72048	15.10417	18.75741	8.653846	8.653846	20
10:50:33 AM	0	62.26852	5	4.16956	4.15254	18.80261	85.72048	15.27778	18.80329	8.653846	8.653846	20
10:50:43 AM	0	61.80556	5	4.201389	4.186288	18.90068	85.72048	15.45139	18.90098	8.653846	8.653846	20
10:50:53 AM	0	61.9213	5	4.265047	4.216287	18.97982	85.72048	15.625	19.13933	8.653846	8.653846	20
10:51:03 AM	0	62.61574	5	4.105903	4.246286	19.26256	85.76389	15.91435	19.25975	8.653846	8.653846	20
10:51:13 AM	0	61.34259	5	4.296875	4.280035	19.15901	85.72048	15.91435	19.15935	8.653846	8.653846	20
10:51:23 AM	0	61.34259	5	4.265047	4.310033	19.28566	85.72048	16.26157	19.28476	8.653846	8.653846	20
10:51:33 AM	0	61.68981	5	4.360533	4.340032	19.29096	85.72048	16.31944	19.29137	8.653846	8.653846	20
10:51:43 AM	0	61.9213	5	4.265047	4.373781	19.46115	85.72048	16.37732	19.49049	8.653846	8.653846	20
10:51:53 AM	0	61.9213	5	4.296875	4.40378	19.55303	85.63368	16.49306	19.55089	8.653846	8.653846	20
10:52:03 AM	0	61.11111	5	4.42419	4.437528	19.62438	85.50347	16.37732	19.62014	8.653846	8.653846	20
10:52:13 AM	0	61.34259	5	4.42419	4.467527	19.77166	85.46007	16.55093	19.86532	8.653846	8.653846	20
10:52:23 AM	0	61.68981	5	4.392361	4.497526	19.82822	85.37327	17.01389	19.82611	8.653846	8.653846	20
10:52:33 AM	0	61.45833	5	4.583333	4.531274	19.71202	85.15625	16.95602	19.70935	8.653846	8.653846	20
10:52:43 AM	0	61.34259	5	4.487847	4.561273	19.84167	85.11285	17.01389	19.868	8.653846	8.653846	20
10:52:53 AM	0	61.45833	5	4.551505	4.591272	19.8225	84.98264	17.24537	19.8217	8.653846	8.653846	20
10:53:03 AM	0	61.34259	5	4.487847	4.621271	19.92371	84.85243	17.07176	19.92104	8.653846	8.653846	20
10:53:13 AM	0	61.45833	5	4.519676	4.655019	20	84.72222	17.12963	19.98689	8.653846	8.653846	20
10:53:23 AM	0	61.9213	5	4.67882	4.685018	19.90514	84.63541	17.07176	19.90501	8.653846	8.653846	20
10:53:33 AM	0	61.45833	5	4.710648	4.715017	19.90438	84.50521	17.41898	19.9043	8.653846	8.653846	20
10:53:43 AM	0	61.68981	5	4.456018	4.748765	20	84.375	17.65046	19.98433	9.801034	10.76923	20
10:53:53 AM	0	61.45833	5	4.742477	4.778764	19.9728	84.24479	17.30324	19.97207	10.76923	10.76923	20

10:54:03 AM	0	60.76389	5	4.551505	4.808763	20	84.11459	17.30324	20	10.76923	10.76923	20
10:54:13 AM	0	61.11111	5	4.869792	4.842512	19.91939	84.02778	17.30324	19.91993	10.76923	10.76923	20
10:54:23 AM	0	61.57407	5	4.42419	4.87251	20	83.89757	17.24537	20	10.76923	10.76923	20
10:54:33 AM	0	61.45833	5	4.67882	4.902509	20	83.81076	17.41898	20	10.76923	10.76923	20
10:54:43 AM	0	61.57407	5	4.519676	4.936258	20	83.63715	17.24537	20	10.76923	10.76923	20
10:54:53 AM	0	61.80556	5	4.67882	4.966257	20	83.59375	17.47685	20	10.76923	10.76923	20
10:55:03 AM	0	61.68981	5	4.67882	4.996255	20	83.50695	17.53472	20	11.09158	12	20
10:55:13 AM	0	61.45833	5	4.551505	5	20	83.42014	17.53472	20	12	12	20
10:55:23 AM	0	61.34259	5	4.67882	5	20	83.37673	17.53472	20	12.52238	13	20
10:55:33 AM	0	61.80556	5	4.646991	5	20	83.28993	17.24537	20	13	13	20
10:55:43 AM	0	61.9213	5	4.774305	5	20	83.20313	17.30324	20	14.88978	15	20
10:55:53 AM	0	61.57407	5	4.646991	5	20	83.11632	17.30324	20	15	15	20
10:56:03 AM	0	61.34259	5	4.615162	5	20	83.07291	17.30324	20	15	15	20
10:56:13 AM	0	60.99537	5	4.774305	5	20	83.07291	17.36111	20	15.55417	18	20
10:56:23 AM	0	61.57407	5	4.710648	5	20	82.98611	17.36111	20	18	18	20
10:56:33 AM	0	61.34259	5	4.67882	5	20	82.98611	17.53472	20	18	18	20
10:56:43 AM	0	61.68981	5	4.551505	5	20	82.8993	17.53472	20	18	18	20
10:56:53 AM	0	62.03704	5	4.710648	5	20	82.8993	17.41898	20	18	18	20
10:57:03 AM	0	62.03704	5	4.742477	5	20	82.8559	17.53472	20	18	18	20
10:57:13 AM	0	61.45833	5	4.646991	5	20	82.8559	17.41898	20	18	18	20
10:57:23 AM	0	62.03704	5	4.774305	5	20	82.8559	17.47685	20	19.549	20	20
10:57:33 AM	0	61.9213	5	4.965278	5	19.99496	82.8559	17.41898	19.99427	20	20	20
10:57:44 AM	0	62.15278	5	4.90162	5	20	82.8993	17.53472	20	20	20	20
10:57:54 AM	0	61.68981	5	4.742477	5	20	82.94271	17.53472	20	21.61268	22	20
10:58:04 AM	0	61.80556	5	4.774305	5	20	82.94271	17.53472	20	22	22	20
10:58:14 AM	0	61.9213	5	4.615162	5	20	83.02952	17.24537	20	23.52774	25	20
10:58:24 AM	0	62.61574	5	4.615162	5	20	83.02952	17.41898	20	25	25	20
10:58:34 AM	0	62.15278	5	4.837963	5	20	83.02952	17.53472	20	25	25	20
10:58:44 AM	0	61.68981	2	3.469329	2	14.96131	83.11632	13.25231	15.02008	24.42587	25	20
10:58:54 AM	0	61.80556	2	3.342014	2	12.25299	83.20313	12.5	12.34285	24.32795	25	20
10:59:04 AM	0	61.11111	2	3.373843	2	10	83.24653	12.44213	10	22.07279	25	20
10:59:14 AM	0	60.76389	2	3.342014	2	10	83.28993	12.44213	10	19.75145	25	20
10:59:24 AM	0	61.45833	2	3.278357	2	10	83.37673	12.44213	10	17.50973	25	20
10:59:34 AM	0	61.11111	2	3.278357	2	10	83.46354	12.44213	10	15.03404	25	20
10:59:44 AM	0	61.9213	2	3.373843	2	10	83.55035	12.44213	10	12.74713	25	20
10:59:54 AM	0	61.57407	2	3.405671	2	10	83.59375	12.5	10	10.32997	25	20
11:00:04 AM	0	61.9213	2	3.405671	2	10	83.63715	12.5	10	7.899109	25	20
11:00:15 AM	0	62.96296	2	3.310185	2	10	83.72395	12.38426	10	5.481563	25	20
11:00:25 AM	0	61.9213	2	3.373843	2	10	83.76736	12.44213	10	3.099009	25	20
11:00:35 AM	0	62.73148	2	3.373843	2	10	83.85417	12.5	10	2	25	20
11:00:45 AM	0	62.61574	2	3.278357	2	10	83.94097	12.5	10	2	25	20
11:00:55 AM	0	62.15278	2	3.405671	2	10	83.94097	12.5	10	2	25	20
11:01:05 AM	0	62.38426	2	3.501158	2	10	83.98438	12.44213	10	2	25	20
11:01:15 AM	0	62.61574	2	3.469329	2	10	84.07117	12.44213	10	2	25	20
11:01:25 AM	0	62.61574	2	3.4375	2	10	84.11459	12.38426	10	2	25	20
11:01:35 AM	0	61.9213	2	3.564815	2	10	84.20139	12.38426	10	2	25	20
11:01:45 AM	0	61.45833	2	3.4375	2	10	84.375	12.38426	10	2	25	20
11:01:55 AM	0	61.80556	2	3.405671	2	10	84.4184	12.38426	10	1.5	25	20
11:02:06 AM	0	61.11111	2	3.564815	2	10	84.59202	12.44213	10	1.5	25	20
11:02:16 AM	0	61.80556	2	3.469329	2	10	84.67883	12.38426	10	1.5	25	20
11:02:26 AM	0	61.34259	2	3.310185	2	10	84.72222	12.38426	10	1.5	25	20
11:02:36 AM	0	62.03704	2	3.405671	2	10	84.89583	12.38426	10	1.5	25	20
11:02:46 AM	0	61.68981	2	3.4375	2	10	84.93924	12.38426	10	1.5	25	20
11:02:56 AM	0	61.68981	2	3.310185	2	10	85.02605	12.38426	10	1.5	25	20
11:03:06 AM	0	61.57407	2	3.405671	2	10	85.15625	12.38426	10	1.5	25	20
11:03:16 AM	0	62.15278	2	3.4375	2	10	85.15625	12.38426	10	1.5	25	20
11:03:26 AM	0	61.80556	2	3.501158	2	10	85.24305	12.38426	10	1.5	25	20
11:03:36 AM	0	60.99537	2	3.4375	2	10	85.32986	12.38426	10	1.5	25	20
11:03:46 AM	0	61.68981	2	3.342014	2	10	85.41666	12.38426	10	1.5	25	20
11:03:57 AM	0	62.26852	2	3.405671	2	10	85.50347	12.44213	10	1	25	20
11:04:07 AM	0	62.5	2	3.564815	2	10	85.54688	12.44213	10	1	25	20
11:04:17 AM	0	61.68981	2	3.405671	2	10	85.59028	12.38426	10	1	25	20
11:04:27 AM	0	61.80556	2	3.373843	2	10	85.59028	12.38426	10	1	25	20
11:04:37 AM	0	61.9213	2	3.4375	2	10	85.67709	12.38426	10	1	25	20
11:04:48 AM	0	60.76389	2	3.4375	2	10	85.67709	12.32639	10	1	25	20
11:04:58 AM	0	61.45833	2	3.278357	2	10	85.76389	12.32639	10	1	25	20
11:05:08 AM	0	61.45833	2	3.405671	2	10	85.72048	12.32639	10	1	25	20
11:05:19 AM	0	60.76389	2	3.373843	2	10	85.76389	12.38426	10	0.5	25	20
11:05:29 AM	0	61.68981	2	3.405671	2	10	85.80729	12.32639	10	0.5	25	20
11:05:39 AM	0	61.9213	2	3.405671	2	10	85.8507	12.44213	10	0.5	25	20
11:05:49 AM	0	61.80556	2	3.246528	2	10	85.80729	12.32639	10	0.5	25	20
11:05:59 AM	0	61.9213	2	3.373843	2	10	85.80729	12.38426	10	0	25	20
11:06:10 AM	0	61.9213	2	3.4375	2	10	85.80729	12.38426	10	0	25	20
11:06:20 AM	0	61.34259	2	3.342014	2	10	85.8507	12.44213	10	0	25	20
11:06:30 AM	0	61.68981	2	3.564815	2	10	85.80729	12.44213	10	0	25	20
11:06:41 AM	0	61.45833	2	3.373843	2	10	85.76389	12.38426	10	0	25	20
11:06:51 AM	0	61.11111	2	3.373843	2	10	85.76389	12.38426	10	0	25	20
11:07:01 AM	0	61.11111	2	3.373843	2	10	85.76389	12.32639	10	0	25	20
11:07:11 AM	0	61.45833	2	3.246528	2	10	85.72048	12.38426	10	0	25	20
11:07:21 AM	0	62.15278	2	3.373843	2	10	85.67709	12.44213	10	0	25	20
11:07:31 AM	0	62.03704	2	3.469329	2	10	85.63368	12.44213	10	0	25	20
11:07:41 AM	0	61.9213	2	3.405671	2	10	85.67709	12.26852	10	0	25	20
11:07:51 AM	0	61.80556	2	3.310185	2	10	85.54688	12.38426	10	0	25	20
11:08:01 AM	0	62.5	2	3.501158	2	10	85.54688	12.38426	10	2	25	20
11:08:11 AM	0	62.03704	2	3.278357	2	10	85.54688	12.38426	10	2	25	20
11:08:21 AM	0	60.99537	2	3.214699	2	10	85.54688	12.38426	10	2	25	20
11:08:31 AM	0	61.34259	2	3.4375	2	10	85.41666	12.44213	10	2	25	20

11:08:41 AM	0	61.57407	2	3.342014	2	10	85.41666	12.38426	10	2	25	20
11:08:51 AM	0	61.57407	2	3.405671	2	10	85.41666	12.38426	10	0	25	20
11:09:01 AM	0	61.57407	2	3.4375	2	10	85.32986	12.44213	10	0	25	20
11:09:11 AM	0	62.61574	2	3.342014	2	10	85.37327	12.38426	10	0	25	20
11:09:21 AM	0	61.68981	2	3.342014	2	10	85.32986	12.44213	10	0	25	20
11:09:32 AM	0	62.5	2	3.246528	2	10	85.24305	12.5	10	0	25	20
11:09:42 AM	0	62.26852	2	3.342014	2	10	85.24305	12.44213	10	0	25	20
11:09:53 AM	0	61.68981	2	3.310185	2	10	85.24305	12.38426	10	0	25	20
11:10:03 AM	0	62.61574	2	3.4375	2	10	85.19965	12.44213	10	0	25	20
11:10:13 AM	0	61.9213	2	3.310185	2	10	85.24305	12.38426	10	0	25	20
11:10:23 AM	0	61.57407	2	3.246528	2	10	85.19965	12.44213	10	0	25	20
11:10:33 AM	0	61.57407	2	3.246528	2	10	85.11285	12.44213	10	0	25	20
11:10:43 AM	0	61.34259	2	3.4375	2	10	85.11285	12.44213	10	0	25	20
11:10:53 AM	0	61.9213	2	3.278357	2	10	85.11285	12.38426	10	0	25	20
11:11:03 AM	0	61.11111	2	3.310185	2	10	85.06944	12.5	10	0	25	20
11:11:13 AM	0	62.15278	2	3.405671	2	10	85.02605	12.5	10	0	25	20
11:11:23 AM	0	61.9213	2	3.342014	2	10	85.06944	12.44213	10	0	25	20
11:11:33 AM	0	60.76389	2	3.310185	2	10	85.02605	12.38426	10	0	25	20
11:11:43 AM	0	61.9213	2	3.310185	2	10	85.02605	12.5	10	0	25	20
11:11:53 AM	0	62.15278	2	3.310185	2	10	84.93924	12.38426	10	0	25	20
11:12:03 AM	0	62.03704	2	3.373843	2	10	84.93924	12.38426	10	0	25	20
11:12:13 AM	0	62.03704	2	3.278357	2	10	84.98264	12.38426	10	0	25	20
11:12:23 AM	0	62.5	2	3.278357	2	10	84.93924	12.5	10	0	25	20
11:12:33 AM	0	61.45833	2	3.246528	2	10	84.93924	12.5	10	0	25	20
11:12:43 AM	0	62.03704	2	3.246528	2	10	84.89583	12.5	10	0	25	20
11:12:53 AM	0	61.34259	2	3.246528	2	10	84.89583	12.44213	10	0	25	20
11:13:03 AM	0	62.73148	2	3.405671	2	10	84.85243	12.44213	10	0	25	20
11:13:13 AM	0	62.38426	2	3.278357	2	10	84.85243	12.5	10	0	25	20
11:13:23 AM	0	61.11111	2	3.405671	2	10	84.89583	12.44213	10	0	25	20
11:13:33 AM	0	61.34259	2	3.342014	2	10	84.85243	12.55787	10	0	25	20
11:13:43 AM	0	61.57407	2	3.342014	2	10	84.85243	12.44213	10	0	25	20
11:13:53 AM	0	62.03704	2	3.501158	2	10	84.76563	12.5	10	0	25	20
11:14:03 AM	0	62.15278	2	3.278357	2	10	84.80903	12.44213	10	0	25	20
11:14:13 AM	0	61.9213	2	3.4375	2	10	84.85243	12.44213	10	0	25	20
11:14:23 AM	0	61.34259	2	3.246528	2	10	84.85243	12.55787	10	0	25	20
11:14:33 AM	0	61.9213	2	3.246528	2	10	84.85243	12.44213	10	0	25	20
11:14:43 AM	0	62.26852	2	3.564815	2	10	84.89583	12.44213	10	0	25	20
11:14:53 AM	0	61.9213	2	3.278357	2	10	84.89583	12.44213	10	0	25	20
11:15:03 AM	0	61.68981	2	3.214699	2	10	84.89583	12.44213	10	0	25	20
11:15:13 AM	0	62.03704	2	3.373843	2	10	84.93924	12.44213	10	0	25	20
11:15:23 AM	0	61.9213	2	3.373843	2	10	84.98264	12.44213	10	0	25	20
11:15:33 AM	0	62.5	2	3.310185	2	10	84.98264	12.55787	10	0	25	20
11:15:43 AM	0	62.26852	2	3.342014	2	10	84.98264	12.44213	10	0	25	20
11:15:53 AM	0	61.9213	2	3.342014	2	10	85.06944	12.5	10	0	25	20
11:16:03 AM	0	61.9213	2	3.373843	2	10	85.06944	12.38426	10	0	25	20
11:16:13 AM	0	61.9213	2	3.4375	2	10	85.11285	12.44213	10	0	25	20
11:16:23 AM	0	62.61574	2	3.342014	2	10	85.11285	12.38426	10	0	25	20
11:16:33 AM	0	62.61574	2	3.214699	2	10	85.15625	12.44213	10	0	25	20
11:16:43 AM	0	62.61574	2	3.310185	2	10	85.19965	12.44213	10	0	25	20
11:16:53 AM	0	61.68981	2	3.342014	2	10	85.15625	12.5	10	0	25	20
11:17:04 AM	0	62.5	2	3.405671	2	10	85.19965	12.38426	10	0	25	20
11:17:14 AM	0	62.26852	2	3.214699	2	10	85.28646	12.44213	10	0	25	20
11:17:24 AM	0	60.30093	2	3.18287	2	10	85.24305	12.44213	10	0	25	20
11:17:34 AM	0	61.45833	2	3.310185	2	10	85.32986	12.38426	10	0	25	20
11:17:45 AM	0	62.03704	2	3.310185	2	10	85.32986	12.38426	10	0	25	20
11:17:55 AM	0	61.68981	2	3.18287	2	10	85.37327	12.38426	10	0	25	20
11:18:05 AM	0	62.26852	2	3.405671	2	10	85.37327	12.38426	10	0	25	20
11:18:15 AM	0	61.68981	2	3.405671	2	10	85.46007	12.38426	10	0	25	20
11:18:25 AM	0	61.57407	2	3.18287	2	10	85.46007	12.38426	10	0	25	20
11:18:35 AM	0	61.80556	2	3.342014	2	10	85.46007	12.44213	10	0	25	20
11:18:45 AM	0	61.9213	2	3.342014	2	10	85.46007	12.44213	10	0	25	20
11:18:55 AM	0	61.9213	2	3.246528	2	10	85.46007	12.38426	10	0	25	20
11:19:05 AM	0	61.9213	2	3.342014	2	10	85.46007	12.5	10	0	25	20
11:19:15 AM	0	61.57407	2	3.278357	2	10	85.46007	12.44213	10	0	25	20
11:19:25 AM	0	61.45833	2	3.278357	2	10	85.50347	12.44213	10	0	25	20
11:19:35 AM	0	61.80556	2	3.373843	2	10	85.50347	12.5	10	0	25	20
11:19:45 AM	0	62.26852	2	3.310185	2	10	85.50347	12.38426	10	0	25	20
11:19:56 AM	0	62.03704	2	3.151042	2	10	85.54688	12.44213	10	0	25	20
11:20:06 AM	0	62.5	2	3.342014	2	10	85.50347	12.44213	10	0	25	20
11:20:16 AM	0	61.9213	2	3.310185	2	10	85.46007	12.44213	10	0	25	20
11:20:26 AM	0	61.45833	2	3.246528	2	10	85.46007	12.44213	10	0	25	20
11:20:36 AM	0	61.11111	2	3.310185	2	10	85.50347	12.44213	10	0	25	20
11:20:46 AM	0	61.57407	2	3.310185	2	10	85.41666	12.38426	10	0	25	20
11:20:57 AM	0	61.68981	2	3.342014	2	10	85.46007	12.44213	10	0	25	20
11:21:07 AM	0	61.11111	2	3.373843	2	10	85.41666	12.44213	10	0	25	20
11:21:17 AM	0	60.99537	2	3.342014	2	10	85.41666	12.5	10	0	25	20
11:21:27 AM	0	61.80556	5	3.214699	5	14.86502	85.41666	12.44213	14.7978	2.753731	26.36364	23
11:21:37 AM	0	61.34259	5	3.18287	5	18.2257	85.41666	12.44213	18.18936	8.856063	26.36364	23
11:21:47 AM	0	61.80556	5	4.16956	5	19.74564	85.46007	15.56713	19.72903	13.52769	26.36364	23
11:21:57 AM	0	62.96296	5	4.551505	5	20.36045	85.46007	17.41898	20.34251	15.95578	26.36364	23
11:22:07 AM	0	62.84722	5	4.646991	5	20.64798	85.41666	17.65046	20.64092	18.54422	26.36364	23
11:22:17 AM	0	62.61574	5	5.060764	5	20.37226	85.37327	18.1713	20.49951	20.57158	26.36364	23
11:22:27 AM	0	62.61574	5	5.124422	5	20.2976	85.24305	17.99768	20.30009	22.6671	26.36364	23
11:22:37 AM	0	62.96296	5	4.997107	5	20.44482	85.24305	18.1713	20.44477	24.90446	26.36364	23
11:22:47 AM	0	62.26852	5	4.710648	5	20.74508	85.28646	17.93982	20.39268	26.36364	26.36364	23
11:22:57 AM	0	62.26852	5	4.997107	5	20.50877	85.28646	18.1713	20.50871	26.36364	26.36364	23
11:23:08 AM	0	62.5	5	5.124422	5	20.39089	85.32986	18.28704	20.39338	26.36364	26.36364	23

11:23:18 AM	0	62.03704	5	5.15625	5	20.37767	85.37327	17.99768	20.38079	26.36364	26.36364	23
11:23:28 AM	0	62.15278	5	5.15625	5	20.39821	85.41666	18.1713	20.59352	26.36364	26.36364	23
11:23:38 AM	0	61.80556	5	4.806134	5	20.81942	85.46007	18.22917	20.81554	26.36364	26.36364	23
11:23:48 AM	0	60.99537	5	4.997107	5	20.67376	85.50347	18.28704	20.6737	27.27273	27.27273	25
11:23:58 AM	0	61.34259	5	4.965278	5	20.72171	85.50347	18.46065	20.72101	25.45455	25.45455	21
11:24:08 AM	0	61.34259	5	4.90162	5	20.82304	85.41666	18.57639	20.82107	25.45455	25.45455	21
11:24:18 AM	0	60.87963	5	5.092592	5	20.59977	85.41666	18.57639	20.60162	25.45455	25.45455	21
11:24:28 AM	0	61.57407	5	5.092592	5	20.63629	85.37327	18.22917	20.63814	25.45455	25.45455	21
11:24:38 AM	0	61.22685	5	4.869792	5	20.89708	85.15625	18.57639	20.89448	25.45455	25.45455	21
11:24:48 AM	0	61.11111	5	4.965278	5	20.82335	85.02605	18.46065	20.82266	25.45455	25.45455	21
11:24:58 AM	0	61.34259	5	4.710648	5	21.09019	84.93924	18.28704	21.08441	25.90909	25.90909	22
11:25:08 AM	0	60.99537	5	4.869792	5	20.91025	84.76563	18.63426	20.71597	25.90909	25.90909	22
11:25:18 AM	0	61.22685	5	5.219908	5	20.58348	84.59202	18.75	20.58788	25.90909	25.90909	22
11:25:28 AM	0	61.11111	5	5.15625	5	20.61033	84.4184	18.63426	20.61346	25.90909	25.90909	22
11:25:38 AM	0	61.34259	5	5.060764	5	20.80405	84.20139	18.75	20.80527	25.90909	25.90909	22
11:25:48 AM	0	61.68981	5	4.806134	5	21.03045	84.07117	18.69213	21.02657	25.90909	25.90909	22
11:25:58 AM	0	60.87963	5	5.092592	5	20.74737	83.89757	18.51852	20.74922	25.90909	25.90909	22
11:26:08 AM	0	60.99537	5	5.092592	5	20.63736	83.68056	18.80787	20.63921	25.90909	25.90909	22
11:26:18 AM	0	60.99537	5	4.933449	5	20.8915	83.55035	18.40278	20.89017	25.90909	25.90909	22
11:26:28 AM	0	60.87963	5	4.837963	5	20.98938	83.37673	18.80787	20.98614	25.90909	25.90909	22
11:26:39 AM	0	61.34259	5	5.15625	5	20.64315	83.20313	18.46065	20.64627	25.90909	25.90909	22
11:26:49 AM	0	60.99537	5	4.997107	5	20.90365	83.02952	18.51852	20.90359	25.90909	25.90909	22
11:26:59 AM	0	61.22685	5	4.965278	5	20.8579	82.8993	18.75	20.85721	25.90909	25.90909	22
11:27:09 AM	0	61.34259	5	4.965278	5	20.81641	82.7691	18.86574	20.81572	25.90909	25.90909	22
11:27:19 AM	0	62.15278	5	5.251736	5	20.56574	82.6823	18.80787	20.57078	25.90909	25.90909	22
11:27:29 AM	0	61.45833	5	5.188078	5	20.61522	82.50868	19.09722	20.61899	26.72727	26.72727	22
11:27:39 AM	0	62.26852	5	5.028935	5	20.7064	82.46528	18.86574	20.70698	26.72727	26.72727	22
11:27:49 AM	0	61.80556	5	5.092592	5	20.62509	82.37847	18.57639	20.84491	26.72727	26.72727	22
11:27:59 AM	0	61.80556	5	5.028935	5	20.68568	82.33508	18.51852	20.68626	26.72727	26.72727	22
11:28:09 AM	0	61.9213	5	5.124422	5	20.51869	82.33508	18.46065	20.52118	26.72727	26.72727	22
11:28:19 AM	0	61.9213	5	4.997107	5	20.6268	82.33508	18.69213	20.62674	26.72727	26.72727	22
11:28:29 AM	0	62.03704	5	5.124422	5	20.59543	82.29166	18.63426	20.59792	26.72727	26.72727	22
11:28:39 AM	0	62.26852	5	5.124422	5	20.49722	82.29166	18.57639	20.49971	26.72727	26.72727	22
11:28:49 AM	0	62.61574	5	4.997107	5	20.60654	82.37847	18.51852	20.60649	26.72727	26.72727	22
11:28:59 AM	0	62.61574	5	4.869792	5	20.72697	82.46528	18.34491	20.72437	26.72727	26.72727	22
11:29:09 AM	0	62.26852	5	4.997107	5	20.57882	82.55208	18.51852	20.57876	26.72727	26.72727	22
11:29:19 AM	0	62.61574	5	5.188078	5	20.44844	82.63889	18.46065	20.4522	26.72727	26.72727	22
11:29:29 AM	0	62.26852	5	5.092592	5	20.54604	82.8125	18.46065	20.67324	26.72727	26.72727	22
11:29:39 AM	0	62.26852	5	5.188078	5	20.32147	82.8559	18.46065	20.32524	26.36364	26.36364	22
11:29:49 AM	0	62.26852	5	5.15625	5	20.36363	82.98611	18.34491	20.36676	28.2	28.2	22
11:29:59 AM	0	62.15278	5	4.837963	5	20.75241	83.15972	18.28704	20.71765	28.2	28.2	22
11:30:09 AM	0	61.9213	5	4.997107	5	20.50591	83.24653	18.46065	20.50585	28.2	28.2	22
11:30:19 AM	0	62.61574	5	4.965278	5	20.59546	83.37673	18.22917	20.59476	28.2	28.2	22
11:30:29 AM	0	62.61574	5	5.028935	5	20.55426	83.50695	18.28704	20.55484	28.2	28.2	22
11:30:39 AM	0	62.03704	5	5.028935	5	20.51653	83.63715	18.46065	20.42257	28.2	28.2	22
11:30:50 AM	0	61.9213	5	5.028935	5	20.54187	83.76736	18.1713	20.54245	28.2	28.2	22
11:31:00 AM	0	62.5	5	4.997107	5	20.54294	83.94097	18.22917	20.54288	28.2	28.2	22
11:31:10 AM	0	62.15278	5	4.997107	5	20.52784	83.98438	17.99768	20.52778	28.61539	28.61539	22
11:31:20 AM	0	61.68981	5	4.806134	5	20.71829	84.15798	18.22917	20.3678	28.61539	28.61539	22
11:31:30 AM	0	62.38426	5	5.219908	5	20.32382	84.20139	18.05556	20.33261	28.61539	28.61539	22
11:31:40 AM	0	61.45833	5	4.806134	5	20.82651	84.28819	18.28704	20.82263	28.61539	28.61539	22
11:31:50 AM	0	61.68981	5	4.997107	5	20.63825	84.3316	18.22917	20.79569	30.48537	33.07692	22
11:32:00 AM	0	62.5	5	4.742477	5	20.92836	84.4184	18.22917	20.92321	32.79133	33.07692	22
11:32:10 AM	0	62.03704	5	4.806134	5	20.86256	84.54861	18.1713	20.85868	33.07692	33.07692	22
11:32:21 AM	0	61.9213	5	5.251736	5	20.46962	84.59202	18.34491	20.47466	33.07692	33.07692	22
11:32:31 AM	0	62.03704	5	4.965278	5	20.67185	84.67883	18.1713	20.67115	33.07692	33.07692	22
11:32:41 AM	0	61.9213	5	4.869792	5	20.77454	84.72222	18.22917	20.76933	33.07692	33.07692	22
11:32:51 AM	0	61.68981	5	4.90162	5	20.80871	84.67883	18.34491	20.80674	33.07692	33.07692	22
11:33:01 AM	0	61.57407	5	4.933449	5	20.83843	84.76563	18.46065	20.8371	33.07692	33.07692	22
11:33:11 AM	0	61.11111	5	4.869792	5	20.85677	84.76563	18.46065	20.85417	33.07692	33.07692	22
11:33:21 AM	0	61.68981	5	4.869792	5	20.84636	84.76563	18.57639	20.84375	33.07692	33.07692	22
11:33:31 AM	0	61.80556	5	5.15625	5	20.55692	84.85243	18.28704	20.62306	33.51088	34.46154	22
11:33:41 AM	0	61.68981	5	4.869792	5	20.86771	84.76563	18.34491	20.86511	34.86853	34.90909	22
11:33:51 AM	0	61.68981	5	5.15625	5	20.5932	84.80903	18.40278	20.59945	34.90909	34.90909	22
11:34:01 AM	0	61.34259	5	5.028935	5	20.80848	84.67883	18.46065	20.90359	34.90909	34.90909	22
11:34:11 AM	0	60.99537	5	5.124422	5	20.65359	84.72222	18.46065	20.65608	34.90909	34.90909	22
11:34:21 AM	0	61.11111	5	4.869792	5	20.89306	84.59202	18.34491	20.89045	34.90909	34.90909	22
11:34:31 AM	0	60.99537	5	4.742477	5	21.14178	84.50521	18.40278	21.10512	34.90909	34.90909	22
11:34:41 AM	0	61.11111	5	5.028935	5	20.84818	84.4184	18.80787	20.84876	34.90909	34.90909	22
11:34:51 AM	0	60.87963	5	5.188078	5	20.70608	84.24479	19.03935	20.70984	34.88363	34.90909	22
11:35:01 AM	0	61.34259	5	5.092592	5	20.86247	84.15798	18.69213	20.86432	34.90909	34.90909	22
11:35:11 AM	0	60.76389	5	5.060764	5	20.88941	83.98438	18.92361	20.89063	34.90909	34.90909	22
11:35:21 AM	0	61.34259	5	5.028935	5	20.90258	83.85417	18.86574	20.90316	34.90909	34.90909	22
11:35:31 AM	0	60.99537	5	4.997107	5	20.89283	83.63715	19.09722	20.89277	34.90909	34.90909	22
11:35:41 AM	0	60.99537	5	4.933449	5	20.96406	83.50695	18.80787	20.99291	34.90909	34.90909	22
11:35:51 AM	0	61.34259	5	4.933449	5	20.91134	83.42014	18.86574	20.91001	34.90909	34.90909	22
11:36:01 AM	0	61.45833	5	5.15625	5	20.79847	83.24653	19.03935	20.80159	34.90909	34.90909	22
11:36:11 AM	0	61.34259	5	4.774305	5	21.3009	83.11632	18.69213	21.29638	34.90909	34.90909	22
11:36:21 AM	0	60.99537	5	5.060764	5	21.18964	82.94271	18.57639	21.19086	34.90909	34.90909	22
11:36:31 AM	0	61.22685	5	4.90162	5	21.44413	82.8125	18.80787	21.44019	34.90909	34.90909	22
11:36:41 AM	0	61.45833	5	4.869792	5	21.35926	82.6823	19.03935	21.35666	34.90909	34.90909	22
11:36:51 AM	0	61.80556	5	5.251736	5	21.01661	82.59549	18.80787	21.08467	34.90909	34.90909	22
11:37:01 AM	0	61.9213	5	5.251736	5	20.96522	82.46528	18.75	20.97026	34.90909	34.90909	22
11:37:11 AM	0	61.9213	5	4.933449	5	21.29323	82.46528	18.69213	21.2919	34.90909	34.90909	22
11:37:21 AM	0	61.57407	2	2.864583	2	15	82.33508	13.59954	15	23.63636	23.63636	15
11:37:31 AM	0	62.26852	2	2.641782	2	15	82.33508	11.05324	15	23.63636	23.63636	15
11:37:41 AM	0	61.11111	2	2.641782	2	14.57598	82.29166	10.87963	14.58882	23.63636	23.63636	15

11:37:51 AM	0	61.11111	2	2.578125	2	13.37571	82.20486	10.9375	13.39883	23.63636	23.63636	15
11:38:01 AM	0	60.99537	2	2.673611	2	12.00005	82.24827	10.87963	12.01353	23.63636	23.63636	15
11:38:11 AM	0	61.57407	2	2.45081	2	11.04941	82.16146	10.87963	11.05843	23.63636	23.63636	15
11:38:22 AM	0	61.34259	2	2.546296	2	10	82.29166	10.99537	10	23.63636	23.63636	15
11:38:32 AM	0	62.73148	2	2.609954	2	10	82.24827	10.9375	10	23.63636	23.63636	15
11:38:42 AM	0	62.15278	2	2.673611	2	9.228758	82.33508	10.9375	9.242229	23.63636	23.63636	15
11:38:52 AM	0	62.26852	2	2.70544	2	8	82.42188	10.99537	8	23.63636	23.63636	15
11:39:02 AM	0	62.03704	2	2.673611	2	8	82.46528	10.99537	8	23.63636	23.63636	15
11:39:12 AM	0	62.61574	2	2.70544	2	8	82.50868	10.99537	8	20.98119	23.63636	15
11:39:22 AM	0	62.5	2	2.70544	2	8	82.55208	10.9375	8	18.05015	23.63636	15
11:39:32 AM	0	62.5	2	2.546296	2	8	82.6823	10.99537	8	15.01784	23.63636	15
11:39:42 AM	0	62.5	2	2.70544	2	8	82.72569	10.99537	8	12.20585	23.63636	15
11:39:52 AM	0	62.61574	2	2.641782	2	7.780887	82.8559	10.99537	7.793723	9.016695	23.63636	15
11:40:02 AM	0	62.5	2	2.70544	2	6.324707	82.8993	10.9375	6.338816	4.054945	23.63636	15
11:40:12 AM	0	62.96296	2	2.578125	2	6	82.98611	10.9375	6	0	23.63636	15
11:40:22 AM	0	62.61574	2	2.70544	2	6	83.07291	10.9375	6	0	23.63636	15
11:40:32 AM	0	62.5	2	2.641782	2	10	83.20313	10.87963	10	2.283162	23.63636	15
11:40:43 AM	0	62.73148	2	2.737268	2	10	83.28993	10.87963	10	1.742575	23.63636	15
11:40:53 AM	0	62.38426	2	2.737268	2	10	83.37673	10.82176	10	1.312875	23.63636	15
11:41:03 AM	0	62.61574	2	2.641782	2	10	83.55035	10.87963	10	0.8574875	23.63636	15
11:41:14 AM	0	62.5	2	2.641782	2	10	83.63715	10.87963	10	0.3357292	23.63636	15
11:41:24 AM	0	62.61574	2	2.578125	2	10	83.72395	10.87963	10	0	23.63636	15
11:41:38 AM	0	62.03704	2	2.70544	2	10	83.81076	10.87963	10	0	23.63636	15
11:41:49 AM	0	61.80556	2	2.609954	2	10	84.02778	10.82176	10	0	23.63636	15
11:42:00 AM	0	61.80556	2	2.769097	2	10	84.15798	10.82176	10	0	23.63636	15
11:42:10 AM	0	61.57407	2	2.609954	2	10	84.28819	10.82176	10	0	23.63636	15
11:42:21 AM	0	61.80556	2	2.769097	2	10	84.46181	10.82176	10	0	23.63636	15
11:42:32 AM	0	62.03704	2	2.70544	2	10	84.63541	10.82176	10	0	23.63636	15
11:42:42 AM	0	62.15278	2	2.70544	2	10	84.72222	10.87963	10	0	23.63636	15
11:42:54 AM	0	62.5	2	2.800926	2	10	84.89583	10.82176	10	0	23.63636	15
11:43:05 AM	0	62.5	2	2.800926	2	10	85.06944	10.82176	10	0	23.63636	15
11:43:16 AM	0	61.68981	2	2.673611	2	10	85.15625	10.82176	10	0	23.63636	15
11:43:26 AM	0	61.34259	2	2.737268	2	10	85.28646	10.82176	10	0	23.63636	15
11:43:36 AM	0	60.99537	2	2.641782	2	10	85.37327	10.82176	10	0	23.63636	15
11:43:46 AM	0	60.99537	2	2.514468	2	10	85.50347	10.3588	10	0.138768	23.63636	15
11:43:58 AM	0	60.99537	2	2.323495	2	10	85.63368	9.895834	10	2	23.63636	15
11:44:09 AM	0	59.83796	2	2.196181	2	10	85.72048	9.895834	10	2	23.63636	15
11:44:19 AM	0	61.80556	2	1.941551	2	10	85.80729	9.606482	10	2	23.63636	15
11:44:29 AM	0	58.68056	2	1.814236	2	10	85.80729	9.085649	10	2	23.63636	15
11:44:39 AM	0	60.30093	2	1.814236	2	10	85.80729	8.969908	10	2	23.63636	15
11:44:49 AM	0	61.68981	2	1.877894	2	8	85.80729	9.143518	8	2	23.63636	15
11:44:59 AM	0	60.99537	2	1.814236	2	8.193821	85.76389	9.143518	8.190105	0.9048409	23.63636	15
11:45:09 AM	0	60.18519	2	1.877894	2	8.377339	85.67709	9.31713	8.374897	0.3524059	23.63636	15
11:45:19 AM	0	59.83796	2	1.877894	2	8.664631	85.63368	9.31713	8.662189	0.211021	23.63636	15
11:45:29 AM	0	60.41667	2	1.846065	2	9.01091	85.54688	9.31713	9.007831	0.2835718	23.63636	15
11:45:39 AM	0	61.22685	2	1.909722	2	9.210875	85.50347	9.259259	9.209069	0.2835149	23.63636	15
11:45:49 AM	0	61.80556	2	1.846065	2	9.512276	85.37327	9.31713	9.509196	0.2835145	23.63636	15
11:45:59 AM	0	61.57407	2	1.877894	2	9.689121	85.28646	9.375	9.686679	0.2835145	23.63636	15
11:46:09 AM	0	61.11111	2	1.177662	2	11.24394	85.19965	8.680555	11.22749	2.266595	23.63636	15
11:46:19 AM	0	61.11111	0	1.177662	0	10.67911	85.11285	8.101851	10.70266	5.892654	23.63636	15
11:46:29 AM	0	60.99537	0	1.114005	0	8.437733	84.98264	8.101851	8.482292	5.859993	23.63636	15
11:46:39 AM	0	60.87963	0	1.177662	0	8	84.85243	8.101851	8	5.870414	23.63636	15
11:46:49 AM	0	60.30093	0	1.082176	0	8	84.76563	8.101851	8	5.870478	23.63636	15
11:46:59 AM	0	60.87963	0	1.177662	0	6.304255	84.63541	8.101851	6.327808	4.695665	23.63636	15
11:47:09 AM	0	61.11111	0	1.273148	0	6	84.59202	8.101851	6	2.602241	23.63636	15
11:47:19 AM	0	60.64815	0	1.114005	0	6	84.375	8.101851	6	0.5849697	23.63636	15
11:47:29 AM	0	61.34259	0	1.241319	0	6	84.28819	8.159722	6	0	23.63636	15
11:47:39 AM	0	61.34259	0	1.145833	0	6	84.15798	8.159722	6	0	23.63636	15
11:47:49 AM	0	60.53241	0	1.114005	0	6	84.02778	8.217592	6	0	23.63636	15
11:47:59 AM	0	60.99537	0	1.145833	0	6	83.89757	8.217592	6	0	23.63636	15
11:48:09 AM	0	60.87963	0	1.145833	0	6	83.76736	8.217592	6	0	23.63636	15
11:48:19 AM	0	61.11111	0	1.082176	0	6	83.59375	8.217592	6	0	23.63636	15
11:48:29 AM	0	60.41667	0	1.336806	0	6	83.50695	8.275463	6	0	23.63636	15
11:48:39 AM	0	60.76389	0	1.082176	0	6	83.33334	8.217592	6	0	23.63636	15
11:48:49 AM	0	61.34259	0	1.273148	0	6	83.24653	8.333334	6	0	23.63636	15
11:48:59 AM	0	60.76389	0	1.304977	0	6	83.11632	8.333334	6	0	23.63636	15
11:49:09 AM	0	61.34259	0	1.177662	0	6	83.02952	8.333334	6	0	23.63636	15
11:49:19 AM	0	61.11111	0	1.304977	0	6	82.98611	8.333334	6	0	23.63636	15
11:49:29 AM	0	61.34259	0	1.209491	0	6	82.8559	8.275463	6	0	23.63636	15
11:49:40 AM	0	61.11111	0	1.336806	0	6	82.7691	8.333334	6	0	23.63636	15
11:49:50 AM	0	60.87963	0	0.9548612	0	6	82.72569	7.87037	6	0	23.63636	15
11:50:00 AM	0	60.99537	0	0.8275463	0	6	82.7691	7.349537	6	0.02230269	23.63636	15
11:50:11 AM	0	61.11111	0	0.859375	0	6	82.6823	7.233796	6	0	23.63636	15
11:50:21 AM	0	60.76389	0	0.7957176	0	6	82.6823	7.175926	6	0	23.63636	15
11:50:31 AM	0	61.11111	0	0.7638889	0	6	82.6823	7.002315	6	0	23.63636	15
11:50:41 AM	0	60.76389	0	0.7638889	0	6	82.63889	6.886574	6	0	23.63636	15
11:50:51 AM	0	61.34259	0	0.6684028	0	6	82.63889	6.712963	6	0	23.63636	15
11:51:02 AM	0	60.76389	0	0.8275463	0	6	82.6823	6.712963	6	0	23.63636	15
11:51:12 AM	0	61.11111	0	0.6684028	0	6	82.63889	6.712963	6	0	23.63636	15
11:51:22 AM	0	60.76389	0	0.9230323	0	6	82.59549	7.175926	6	0	23.63636	15
11:51:32 AM	0	60.76389	0	0.9230323	0	6	82.55208	7.581018	6	0	23.63636	15
11:51:42 AM	0	60.99537	0	0.9866899	0	6	82.59549	7.75463	6	0	23.63636	15
11:51:53 AM	0	61.11111	0	0.9866899	0	6	82.59549	7.8125	6	0	23.63636	15
11:52:03 AM	0	60.18519	0	0.9866899	0	6	82.55208	7.8125	6	0	23.63636	15
11:52:13 AM	0	61.11111	0	0.9548612	0	6	82.50868	7.8125	6	0	23.63636	15
11:52:23 AM	0	61.11111	0	1.018519	0	6	82.50868	7.8125	6	0	23.63636	15
11:52:33 AM	0	60.76389	0	1.018519	0	6	82.55208	7.8125	6	0	23.63636	15

11:52:43 AM	0	60.99537	0	1.018519	0	6	82.46528	7.8125	6	0	23.63636	15
11:52:53 AM	0	60.76389	0	0.9548612	0	6	82.46528	7.75463	6	0	23.63636	15
11:53:04 AM	0	60.99537	0	0.9230323	0	6	82.46528	7.8125	6	0	23.63636	15
11:53:15 AM	0	60.87963	0	1.018519	0	6	82.42188	7.87037	6	0	23.63636	15
11:53:25 AM	0	60.99537	0	0.9866899	0	6	82.37847	7.87037	6	0	23.63636	15
11:53:35 AM	0	61.11111	0	0.9548612	0	6	82.42188	7.8125	6	0	23.63636	15
11:53:45 AM	0	61.11111	0	1.082176	0	6	82.42188	7.8125	6	0	23.63636	15
11:53:55 AM	0	60.76389	0	1.018519	0	6	82.37847	7.8125	6	0	23.63636	15
11:54:05 AM	0	61.34259	0	0.9866899	0	6	82.42188	7.8125	6	0	23.63636	15
11:54:15 AM	0	60.53241	0	0.9548612	0	6	82.37847	7.8125	6	1	23.63636	15
11:54:25 AM	0	60.87963	0	1.050347	0	6	82.29166	7.8125	6	1	23.63636	15
11:54:35 AM	0	60.87963	0	0.9866899	0	6	82.29166	7.8125	6	1	23.63636	15
11:54:45 AM	0	61.11111	0	1.018519	0	6	82.33508	7.8125	6	1	23.63636	15
11:54:55 AM	0	60.99537	0	1.018519	0	6	82.33508	7.8125	6	1	23.63636	15
11:55:05 AM	0	60.87963	0	0.9866899	0	6	82.42188	7.8125	6	1	23.63636	15
11:55:15 AM	0	60.99537	0	0.9230323	0	6	82.42188	7.8125	6	1	23.63636	15
11:55:25 AM	0	60.87963	10	1.018519	10	15.8445	82.37847	7.87037	15.66487	4.756171	39	27.625
11:55:35 AM	0	60.99537	10	5.474537	10	25.8015	82.42188	17.01389	25.90006	18.61802	39	27.625
11:55:45 AM	0	61.57407	10	7.320602	10	27.625	82.46528	23.14815	27.625	22.34689	39	27.625
11:55:55 AM	0	61.80556	10	6.715857	10	27.625	82.50868	23.37963	27.625	26.75562	39	27.625
11:56:05 AM	0	62.03704	10	6.811342	10	27.625	82.6823	23.32176	27.625	31.51936	39	27.625
11:56:15 AM	0	62.03704	10	6.715857	10	27.625	82.8993	23.14815	27.625	36.23721	39	27.625
11:56:25 AM	0	62.03704	10	7.35243	10	27.625	83.20313	23.03241	27.625	39	39	27.625
11:56:35 AM	0	62.03704	10	6.684028	10	27.625	83.50695	22.91667	27.625	39	39	27.625
11:56:45 AM	0	62.15278	10	6.556713	10	27.625	83.85417	23.09028	27.625	39	39	27.625
11:56:55 AM	0	62.03704	10	7.447917	10	27.625	84.20139	23.03241	27.625	39	39	27.625
11:57:05 AM	0	61.9213	10	7.288773	10	27.625	84.54861	22.8588	27.625	39	39	27.625
11:57:15 AM	0	61.68981	10	7.416089	10	27.625	84.85243	22.74306	27.625	39	39	27.625
11:57:26 AM	0	61.45833	10	7.256945	10	27.625	85.19965	22.80093	27.625	39	39	27.625
11:57:36 AM	0	60.99537	10	7.034144	10	27.625	85.54688	23.03241	27.625	39	39	27.625
11:57:46 AM	0	60.76389	10	6.811342	10	27.625	85.80729	22.4537	27.625	39	39	27.625
11:57:56 AM	0	60.30093	10	6.684028	10	27.625	86.02431	22.74306	27.625	39	39	27.625
11:58:06 AM	0	59.72222	10	14.60938	10	17.77894	86.11111	36.16898	17.87112	20.96433	39	27.625
11:58:16 AM	0	58.10185	10	9.230324	10	23.56785	86.15451	27.83565	23.55246	19.8041	39	27.625
11:58:26 AM	0	58.56481	10	9.389468	10	24.85938	86.11111	28.58797	24.84716	15.92143	39	27.625
11:58:36 AM	0	59.60648	10	9.389468	10	26.25637	86.02431	28.81944	26.24416	13.6871	39	27.625
11:58:46 AM	0	59.375	10	9.293982	10	27.42066	85.8941	28.41435	27.40654	13.25249	39	27.625
11:58:56 AM	0	59.375	10	8.816551	10	27.625	85.63368	28.24074	27.625	12.94816	39	27.625
11:59:06 AM	0	59.25926	10	9.262153	10	27.625	85.32986	28.125	27.625	12.89663	39	27.625
11:59:16 AM	0	59.60648	10	8.59375	10	27.625	85.02605	28.24074	27.625	12.78241	39	27.625
11:59:26 AM	0	59.25926	10	8.816551	10	27.625	84.72222	28.06713	27.625	12.80642	39	27.625
11:59:36 AM	0	59.60648	10	8.848379	10	27.625	84.3316	28.24074	27.625	12.64324	39	27.625
11:59:46 AM	0	59.375	10	8.498264	10	27.625	83.94097	28.125	27.625	12.6726	39	27.625
11:59:56 AM	0	59.60648	10	9.007524	10	27.625	83.63715	27.66203	27.625	12.66905	39	27.625
12:00:06 PM	0	59.49074	10	9.166667	10	27.625	83.28993	27.89352	27.625	12.66904	39	27.625
12:00:16 PM	0	59.72222	10	8.721066	10	27.625	82.94271	27.83565	27.625	12.66904	39	27.625
12:00:26 PM	0	60.06944	10	8.625579	10	27.625	82.63889	27.77778	27.625	12.66904	39	27.625
12:00:36 PM	0	59.83796	10	8.657407	10	27.625	82.42188	27.83565	27.625	12.66904	39	27.625
12:00:46 PM	0	59.9537	10	8.625579	10	30	82.16146	27.60417	30	15.12213	40.2	30
12:00:56 PM	0	59.83796	10	8.816551	10	30	82.03125	27.71991	30	17.26063	40.2	30
12:01:06 PM	0	60.18519	10	9.612268	10	29.657	81.81423	28.18287	30	18.6211	40.2	30
12:01:16 PM	0	60.30093	10	9.994213	10	29.50657	81.68403	28.93518	29.50634	18.67202	40.2	30
12:01:26 PM	0	60.41667	10	9.866899	10	29.71505	81.64063	29.45602	29.71238	18.98338	40.2	30
12:01:36 PM	0	60.76389	10	9.771412	10	29.92581	81.64063	29.57176	29.92124	19.00235	40.2	30
12:01:46 PM	0	60.99537	10	9.994213	10	30	81.68403	29.74537	30	19.01929	40.2	30
12:01:56 PM	0	61.11111	10	10.50347	10	28.66719	81.77084	29.91898	28.67726	18.41108	40.2	30
12:02:06 PM	0	60.99537	10	10.0897	10	28.6219	81.90104	29.22453	28.6237	18.19781	40.2	30
12:02:16 PM	0	61.34259	10	10.3125	10	27.84728	82.03125	29.6875	27.72749	16.48764	40.2	30
12:02:26 PM	0	61.45833	10	9.516782	10	27.97897	82.20486	29.34028	27.9693	15.09596	40.2	30
12:02:36 PM	0	61.57407	10	9.644097	10	28.04222	82.50868	28.64583	28.0351	14.25258	40.2	30
12:02:46 PM	0	61.68981	20	11.4265	20	38.39132	82.72569	29.16667	39.33333	25.90524	42.06667	39.33333
12:02:56 PM	0	61.45833	20	15.21412	20	39.33333	82.94271	34.25926	39.33333	30.68683	42.06667	39.33333
12:03:06 PM	0	61.45833	20	17.47396	20	39.2783	83.24653	36.9213	39.22778	32.78804	42.06667	39.33333
12:03:16 PM	0	61.68981	20	18.17419	20	39.11812	83.59375	37.78935	39.33333	33.91344	42.06667	39.33333
12:03:26 PM	0	61.9213	20	18.55613	20	39.33333	83.98438	38.4838	39.33333	34.29727	42.06667	39.33333
12:03:36 PM	0	62.61574	20	18.93808	20	39.3195	84.375	38.65741	39.29826	34.28834	42.06667	39.33333
12:03:46 PM	0	62.61574	20	19.06539	20	39.67709	84.85243	39.00463	39.6397	34.15246	42.4	41
12:03:56 PM	0	62.61574	20	19.89294	20	40.33183	85.41666	39.29398	41	36.11146	42.4	41
12:04:06 PM	0	62.15278	20	19.9566	20	40.62419	85.9375	40.16204	40.62332	35.94918	42.4	41
12:04:16 PM	0	61.22685	20	20.05208	20	40.58999	86.58854	40.10416	40.59103	36.06189	42.4	41
12:04:26 PM	0	61.11111	20	19.82928	20	40.80521	87.19618	40.33565	41	36.28694	42.4	41
12:04:36 PM	0	60.87963	20	19.54282	20	41	87.67361	40.45139	41	36.38675	42.4	41
12:04:46 PM	0	59.83796	20	19.92477	20	40.93732	88.10764	40.45139	40.93582	36.40168	42.4	41
12:04:56 PM	0	59.49074	20	19.70197	20	41	88.49826	40.56713	41	36.41114	42.4	41
12:05:06 PM	0	59.14352	20	19.47917	20	42	88.67188	40.625	42	37.55722	42.6	42
12:05:16 PM	0	59.49074	20	19.63831	20	42	88.75867	41.55093	42	37.46805	42.6	42
12:05:26 PM	0	59.375	20	19.47917	20	42	88.67188	41.31945	42	37.65494	42.6	42
12:05:36 PM	0	59.02778	20	19.41551	20	42.80471	88.41145	41.66666	42.79303	38.19846	42.8	43
12:05:46 PM	0	58.33333	20	19.63831	20	42.9489	88.15104	42.01389	42.94167	38.64231	42.8	43
12:05:56 PM	0	59.14352	20	19.41551	20	43	87.76041	42.36111	43	38.85397	42.8	43
12:06:06 PM	0	58.91204	20	19.63831	20	43	87.3698	42.59259	43	38.80316	42.8	43
12:06:16 PM	0	59.02778	20	19.79745	20	42.98831	86.89236	42.82407	42.70066	38.80656	42.8	43
12:06:26 PM	0	59.14352	20	20.11574	20	42.70275	86.54514	42.59259	42.70506	38.80659	42.8	43
12:06:36 PM	0	60.18519	20	20.08391	20	42.52321	86.0677	42.93982	42.52489	38.76308	42.8	43
12:06:46 PM	0	60.18519	30	19.9566	30	52.79057	85.72048	42.88195	52.36913	44.42103	55	55
12:06:56 PM	0	60.99537	30	26.35417	30	54.69725	85.50347	50.9838	54.62433	50.44049	55	55
12:07:06 PM	0	60.87963	500	26.99074	58.52469	82	85.19965	52.31481	82	100	100	82

12:07:16 PM	0	60.87963	60	27.30903	60	25.43538	85.06944	62.67361	24.78156	25.86754	100	82
12:07:26 PM	0	60.99537	60	28.35938	60	82	85.11285	49.13195	82	78.41097	100	82
12:07:36 PM	0	61.80556	60	45.54688	60	82	85.28646	74.65278	82	85.59299	100	82
12:07:46 PM	0	61.80556	60	47.6794	60	82	85.50347	77.37269	82	90.10934	100	82
12:07:56 PM	0	62.96296	60	50.73495	60	82	85.9375	78.35648	82	93.0786	100	82
12:08:06 PM	0	63.88889	60	52.89931	60	82	86.63194	79.1088	81.98174	95.783	100	82
12:08:16 PM	0	64.00463	60	53.63136	60	82	87.67361	79.51389	82	98.15264	100	82
12:08:26 PM	0	63.77315	60	55.25463	60	82	88.84548	79.34028	82	100	100	82
12:08:36 PM	0.1989285	63.65741	60	55.79572	60	82.02188	90.19097	79.51389	82.02188	100	100	82.02188
12:08:46 PM	1.736108	62.15278	60	55.57291	60	82.19097	91.66666	79.28241	82.19097	100	100	82.19097
12:08:56 PM	3.228076	61.57407	60	55.03183	60	82.35509	93.09895	79.51389	82.35509	100	100	82.35509
12:09:06 PM	4.584424	59.83796	60	54.84086	60	82.50429	94.40105	79.34028	82.50429	100	100	82.50429
12:09:16 PM	5.759907	58.91204	60	53.82234	60	82.63359	95.52951	79.22454	82.63359	100	100	82.63359
12:09:26 PM	6.618921	58.91204	60	53.59954	60	82.72808	96.35416	79.80324	82.71814	100	100	82.72808
12:09:36 PM	7.071034	58.33333	60	52.16725	60	82.77782	96.7448	79.57176	82.77782	100	100	82.77782
12:09:46 PM	7.161458	58.44907	60	52.64468	60	82.78776	96.875	79.6875	82.78776	100	100	82.78776
12:09:56 PM	7.116246	58.56481	60	52.03993	60	82.78278	96.8316	79.86111	82.78278	100	100	82.78278
12:10:06 PM	6.799769	60.06944	60	51.94444	60	82.74798	96.52778	80.15046	82.74798	100	100	82.74798
12:10:16 PM	6.392868	60.30093	60	51.91261	60	82.70322	96.13715	80.43981	82.70322	100	100	82.70322
12:10:26 PM	5.985967	60.87963	60	51.62616	60	82.65845	95.74653	80.09259	82.65845	100	100	82.65845
12:10:36 PM	5.533854	61.22685	60	52.10359	60	82.60873	95.3125	80.15046	82.60873	100	100	82.60873
12:10:46 PM	5.126953	60.99537	60	51.94444	60	82.56396	94.92188	80.15046	82.56396	100	100	82.56396
12:10:56 PM	4.810468	61.34259	60	52.74016	60	82.52915	94.61805	80.43981	82.52915	100	100	82.52915
12:11:06 PM	4.584424	61.45833	60	53.72685	60	82.50429	94.40105	80.43981	82.50429	99.99528	100	82.50429
12:11:16 PM	4.403575	60.99537	60	53.18576	60	82.48439	94.31424	80.15046	82.48439	100	100	82.48439
12:11:26 PM	4.403575	61.9213	60	53.40857	60	82.48439	94.22743	80.15046	82.48439	100	100	82.48439
12:11:36 PM	4.493999	62.26852	60	53.91782	60	82.49434	94.31424	79.86111	82.49434	100	100	82.49434
12:11:46 PM	4.584424	61.9213	60	54.36343	60	82.50429	94.40105	80.43981	82.50429	100	100	82.50429
12:11:56 PM	4.720052	61.9213	60	53.56771	60	82.5192	94.53125	79.86111	82.5192	100	100	82.5192
12:12:06 PM	4.991317	61.34259	60	54.23611	60	82.54904	94.79166	79.86111	82.54904	100	100	82.54904
12:12:16 PM	5.126953	61.68981	60	53.85417	60	82.56396	95.00868	79.80324	82.56396	100	100	82.56396
12:12:26 PM	5.353014	60.76389	60	54.5544	60	82.58883	95.13889	80.03472	82.58883	100	100	82.58883
12:12:36 PM	5.624278	61.68981	60	53.94965	60	82.61867	95.39931	79.86111	82.61867	100	100	82.61867
12:12:46 PM	5.759907	61.34259	60	54.23611	60	82.63359	95.52951	79.6875	82.63359	100	100	82.63359
12:12:56 PM	5.850331	62.61574	60	53.98148	60	82.64354	95.65972	80.15046	82.64354	100	100	82.64354
12:13:06 PM	5.940755	61.68981	60	53.94965	60	82.65348	95.70313	79.91898	82.65348	100	100	82.65348
12:13:16 PM	5.985967	62.15278	60	54.1088	60	82.65845	95.74653	80.43981	82.65845	100	100	82.65845
12:13:26 PM	5.985967	61.22685	60	54.71354	60	82.65845	95.74653	80.15046	82.65845	100	100	82.65845
12:13:36 PM	5.985967	62.61574	60	53.66319	60	82.65845	95.74653	80.20833	82.65845	100	100	82.65845
12:13:46 PM	5.985967	62.26852	60	54.3316	60	82.65845	95.74653	80.03472	82.65845	100	100	82.65845
12:13:56 PM	5.940755	61.80556	60	54.84086	60	82.65348	95.70313	80.15046	82.65348	100	100	82.65348
12:14:06 PM	5.850331	61.34259	60	54.61806	60	82.64354	95.61632	79.80324	82.64354	100	100	82.64354
12:14:16 PM	5.805127	62.15278	60	54.45891	60	82.63857	95.57292	80.20833	82.63857	100	100	82.63857
12:14:26 PM	5.669482	62.03704	60	54.29977	60	82.62364	95.4427	80.15046	82.62364	100	100	82.62364
12:14:36 PM	5.579066	62.84722	60	54.90451	60	82.6137	95.3559	80.43981	82.6137	100	100	82.6137
12:14:46 PM	5.624278	62.84722	60	54.45891	60	82.61867	95.39931	79.74537	82.61867	100	100	82.61867
12:14:56 PM	5.533854	63.88889	60	54.93634	60	82.60873	95.3125	80.15046	82.60873	100	100	82.60873
12:15:06 PM	5.533854	63.42593	60	55.54109	60	82.60873	95.3559	80.15046	82.60873	100	100	82.60873
12:15:16 PM	5.533854	63.77315	60	55.25463	60	82.60873	95.3125	80.15046	82.60873	100	100	82.60873
12:15:26 PM	5.579066	63.65741	60	55.09549	60	82.6137	95.3559	80.20833	82.6137	100	100	82.6137
12:15:36 PM	5.669482	63.88889	60	55.54109	60	82.62364	95.4427	80.2662	82.62364	100	100	82.62364
12:15:46 PM	5.759907	63.77315	60	55.89121	60	82.63359	95.52951	80.03472	82.63359	100	100	82.63359
12:15:56 PM	5.850331	63.88889	60	56.46412	60	82.64354	95.61632	80.2662	82.64354	100	100	82.64354
12:16:06 PM	5.985967	64.00463	60	56.20949	60	82.65845	95.74653	80.32407	82.65845	100	100	82.65845
12:16:16 PM	6.166816	62.61574	60	56.30497	60	82.67834	95.92014	79.86111	82.67834	100	100	82.67834
12:16:26 PM	6.21202	62.96296	60	56.36863	60	82.68332	95.96354	80.20833	82.68332	100	100	82.68332
12:16:36 PM	6.302444	64.58333	60	56.33681	60	82.69327	96.05035	80.15046	82.69824	100	100	82.69327
12:16:46 PM	6.392868	63.77315	60	55.82754	60	82.70322	96.13715	80.20833	82.70322	100	100	82.70322
12:16:56 PM	6.483292	64.12037	60	55.4456	60	82.71317	96.22396	79.80324	82.71317	100	100	82.71317
12:17:06 PM	6.528496	63.19444	60	56.17766	60	82.71814	96.26736	79.80324	82.70818	100	100	82.71814
12:17:16 PM	6.528496	65.0463	60	56.84607	60	82.71814	96.31077	80.43981	82.71814	100	100	82.71814
12:17:26 PM	6.573717	64.35185	60	56.17766	60	82.72311	96.31077	80.2662	82.72311	100	100	82.72311
12:17:36 PM	6.528496	65.0463	50	56.59143	50	66.60855	96.26736	80.15046	66.74039	85.47195	87.84908	75.63523
12:17:46 PM	6.573717	63.19444	1	32.87905	1	6.695782	96.31077	65.16204	7.333363	1.511396	23.63636	15
12:17:56 PM	6.43808	58.33333	1	4.646991	1	10.26582	96.18056	24.71065	10.33876	2.231907	23.63636	15
12:18:06 PM	6.573717	60.99537	1	1.336806	1	11.4865	96.31077	9.548612	11.49997	8.013124	23.63636	15
12:18:16 PM	6.573717	60.53241	1	1.114005	1	11.31763	96.31077	8.506945	11.31992	11.13673	23.63636	15
12:18:26 PM	6.302444	58.56481	1	1.145833	1	10.989	96.05035	8.564815	10.99191	13.53219	23.63636	15
12:18:36 PM	6.166816	63.77315	1	1.336806	1	10.19555	95.92014	8.912037	10.20228	14.41348	23.63636	15
12:18:46 PM	6.031171	64.00463	1	1.368634	1	9.318816	95.78992	9.31713	9.326188	14.20196	23.63636	15
12:18:56 PM	5.850331	65.16204	1	1.591435	1	8.133613	95.61632	9.375	8.302994	13.65944	23.63636	15
12:19:06 PM	5.624278	65.27778	1	1.495949	1	7.200228	95.39931	9.43287	7.210146	11.53226	23.63636	15
12:19:16 PM	5.307794	65.0463	1	1.527778	1	6.104354	95.09548	9.31713	6.11491	8.305577	23.63636	15
12:19:26 PM	4.900892	63.88889	1	1.368634	1	6	94.70486	8.969908	6	5.336303	23.63636	15
12:19:36 PM	4.493999	62.84722	1	1.336806	1	6	94.31424	8.738426	6	2.669985	23.63636	15
12:19:46 PM	4.13231	65.16204	1	1.082176	1	6.066669	93.96702	8.217592	6.068312	1.028798	23.63636	15
12:19:56 PM	3.680189	65.0463	1	1.495949	1	6	93.53298	8.333334	6	1	23.63636	15
12:20:06 PM	3.3185	63.65741	1	1.368634	1	6	93.09895	8.391204	6	0	23.63636	15
12:20:16 PM	2.821183	64.12037	1	1.273148	1	6	92.70834	8.391204	6	0	23.63636	15
12:20:26 PM	2.414282	63.31019	1	1.46412	1	6	92.31771	8.449074	6	0	23.63636	15
12:20:36 PM	1.962169	64.46759	1	1.432292	1	6	91.88368	8.391204	6	0	23.63636	15
12:20:46 PM	1.555268	64.46759	1	1.527778	1	6	91.49306	8.449074	6	0	23.63636	15
12:20:56 PM	1.103155	64.58333	1	1.336806	1	6	91.05903	8.449074	6	0	23.63636	15
12:21:06 PM	0.6510416	63.77315	1	1.336806	1	6	90.625	8.449074	6	0	23.63636	15
12:21:16 PM	0.2441406	63.77315	1	1.368634	1	6	90.23438	8.449074	6	0	23.63636	15
12:21:26 PM	0	63.19444	1	1.432292	1	6	89.88715	8.506945	6	0	23.63636	15
12:21:36 PM	0	64.35185	1	1.400463	1	6	89.45313	8.564815	6	0	23.63636	15

12:21:46 PM	0	64.46759	1	1.336806	1	6	89.0191	8.564815	6	0	23.63636	15
12:21:56 PM	0	65.0463	1	1.432292	1	6	88.62847	8.506945	6	0	23.63636	15
12:22:06 PM	0	65.0463	1	1.46412	1	6	88.28125	8.564815	6	0	23.63636	15
12:22:16 PM	0	65.0463	1	1.368634	1	6	87.97743	8.564815	6	0	23.63636	15
12:22:26 PM	0	64.00463	1	1.495949	1	6	87.71702	8.564815	6	0	23.63636	15
12:22:36 PM	0	65.97222	1	1.591435	1	6	87.41319	8.564815	6	0	23.63636	15
12:22:46 PM	0	65.0463	1	1.591435	1	6	87.10938	8.564815	6	0	23.63636	15
12:22:56 PM	0	65.0463	1	1.495949	1	6	86.89236	8.506945	6	0	23.63636	15
12:23:06 PM	0	64.58333	1	1.432292	1	6	86.67535	8.506945	6	0	23.63636	15
12:23:16 PM	0	64.58333	1	1.432292	1	6	86.54514	8.506945	6	0	23.63636	15
12:23:26 PM	0	64.58333	1	1.273148	1	6	86.32813	8.506945	6	0	23.63636	15
12:23:36 PM	0	63.0787	1	1.209491	1	6	86.24132	8.449074	6	0	23.63636	15
12:23:46 PM	0	63.0787	1	1.273148	1	6	86.0677	8.449074	6	0	23.63636	15
12:23:56 PM	0	63.42593	1	1.336806	1	6	85.9375	8.391204	6	0	23.63636	15
12:24:06 PM	0	63.77315	1	1.495949	1	6	85.76389	8.449074	6	0	23.63636	15
12:24:16 PM	0	63.42593	1	1.46412	1	6	85.72048	8.506945	6	0	23.63636	15
12:24:26 PM	0	64.58333	1	1.432292	1	6	85.54688	8.506945	6	0	23.63636	15
12:24:36 PM	0	63.42593	1	1.145833	1	6	85.46007	8.275463	6	0	23.63636	15
12:24:46 PM	0	63.77315	1	1.241319	1	6	85.28646	8.217592	6	0	23.63636	15
12:24:56 PM	0	62.26852	1	1.209491	1	6	85.19965	8.217592	6	0	23.63636	15
12:25:06 PM	0	63.31019	1	1.145833	1	6	85.06944	8.275463	6	0	23.63636	15
12:25:16 PM	0	63.77315	1	1.241319	1	6	84.93924	8.275463	6	0	23.63636	15
12:25:26 PM	0	63.77315	1	1.336806	1	6	84.85243	8.333334	6	0	23.63636	15
12:25:36 PM	0	64.69907	1	1.145833	1	6	84.76563	8.275463	6	0	23.63636	15
12:25:46 PM	0	63.77315	1	1.336806	1	6	84.63541	8.391204	6	0	23.63636	15
12:25:56 PM	0	63.88889	30	2.832755	5.048225	35.18831	84.54861	8.391204	35.18831	55	55	55
12:26:06 PM	0	65.625	30	21.57986	20.40316	35.18831	84.4184	36.63195	35.18831	55	55	55
12:26:16 PM	0	65.85648	60	34.24768	34.56597	61.79063	84.3316	55.38194	61.79063	100	100	82
12:26:26 PM	0	66.66667	60	46.05614	48.13079	61.79063	84.4184	65.45139	61.79063	100	100	82
12:26:36 PM	0	67.47685	60	57.38715	60	63.43443	84.72222	80.84491	63.38218	95.59143	100	82
12:26:46 PM	0	68.63426	60	57.48264	60	68.00999	85.37327	80.55556	67.95964	80.49622	100	82
12:26:56 PM	0	70.13889	60	56.59143	60	75.49367	86.58854	75.63657	75.42549	81.34924	100	82
12:27:06 PM	0	70.48611	60	58.85128	60	78.68686	88.19445	75.11574	78.66388	85.5909	100	82
12:27:16 PM	0.2441406	68.86574	60	59.45602	60	79.18005	90.23438	76.04167	79.16917	88.30146	100	82.02686
12:27:26 PM	2.640335	66.43519	60	60.34722	60	76.85605	92.53472	76.73611	76.86299	87.16989	100	82.29044
12:27:36 PM	4.900892	63.77315	60	59.48785	60	77.34451	94.83507	76.44676	76.92462	87.19336	100	82.5391
12:27:46 PM	7.297094	62.96296	60	58.97859	60	79.5217	97.00521	77.31481	79.50127	89.67638	100	82.80268
12:27:56 PM	9.195963	59.72222	60	57.60996	60	83.01156	98.82813	78.24074	83.00161	95.81236	100	83.01156
12:28:06 PM	10.46188	59.49074	60	56.49594	60	83.15081	100.0868	78.41435	83.15081	100	100	83.15081
12:28:16 PM	11.04963	58.91204	60	55.89121	60	83.21545	100.6076	78.99306	83.21545	100	100	83.21545
12:28:26 PM	11.14004	61.34259	60	55.03183	60	83.22541	100.6944	79.57176	83.22541	100	100	83.22541
12:28:36 PM	10.73314	61.9213	60	54.1088	60	83.18065	100.2604	79.51389	83.18065	100	100	83.18065
12:28:46 PM	10.00977	60.76389	60	54.14063	60	83.10107	99.60938	79.57176	83.10107	100	100	83.10107
12:28:56 PM	9.150751	63.19444	60	53.82234	60	83.00658	98.78472	79.86111	83.00658	100	100	83.00658
12:29:06 PM	8.246532	63.54167	60	54.5544	60	82.90712	97.91667	79.86111	82.91209	100	100	82.90712
12:29:16 PM	7.523147	64.12037	60	56.65509	60	82.82755	97.13541	79.74537	82.82755	100	100	82.82755
12:29:26 PM	6.799769	64.23611	60	56.40046	60	82.74798	96.52778	80.6713	82.74798	99.98944	100	82.74798
12:29:36 PM	6.257232	64.69907	60	55.95486	60	82.6883	96.00694	80.20833	82.6883	100	100	82.6883
12:29:46 PM	5.940755	65.27778	60	57.38715	60	82.65348	95.70313	79.86111	82.65348	100	100	82.65348
12:29:56 PM	5.805127	64.35185	60	57.92824	60	82.63857	95.57292	80.43981	82.63857	100	100	82.63857
12:30:06 PM	5.805127	65.625	60	58.15104	60	82.63857	95.57292	80.43981	82.63857	100	100	82.63857
12:30:16 PM	5.985967	65.0463	60	59.32871	60	82.65707	95.74653	80.78704	82.29705	100	100	82.65845
12:30:26 PM	6.347656	65.0463	60	58.72396	60	82.69824	96.09375	80.78704	82.69824	100	100	82.69824
12:30:36 PM	6.799769	65.16204	60	59.23322	60	82.74798	96.52778	80.72917	82.74798	100	100	82.74798
12:30:46 PM	7.251874	64.69907	60	59.16956	60	82.79771	96.9618	80.43981	82.79771	100	100	82.79771
12:30:56 PM	7.658783	63.77315	60	60.21991	60	82.07965	97.35243	80.96065	82.08405	100	100	82.84246
12:31:06 PM	8.065684	62.73148	60	59.90162	60	82.14886	97.74306	81.07639	82.1469	100	100	82.88722
12:31:16 PM	8.336949	63.88889	60	60.06076	60	81.7614	98.00347	81.42361	81.76261	99.80791	100	82.91706
12:31:26 PM	8.698638	63.19444	60	60.28357	60	81.73128	98.4375	81.65509	82.65076	100	100	82.95686
12:31:36 PM	8.969903	62.96296	60	59.64699	60	82.38075	98.61111	81.94444	82.36664	99.83973	100	82.98669
12:31:46 PM	9.105547	63.19444	60	60.66551	60	81.67633	98.74133	81.8287	81.68964	99.87626	100	83.00161
12:31:56 PM	9.195963	63.77315	60	59.80613	60	82.77394	98.78472	81.65509	82.95912	100	100	83.01156
12:32:06 PM	9.150751	63.19444	60	59.36053	60	83.00658	98.78472	82.06019	83.00658	100	100	83.00658
12:32:16 PM	9.195963	62.5	60	60.02893	60	82.58189	98.82813	82.17593	82.58247	99.91069	100	83.01156
12:32:26 PM	9.105547	63.0787	60	59.42419	60	83.00161	98.69791	82.06019	82.16518	99.92328	100	83.00161
12:32:36 PM	8.924699	63.77315	60	59.77431	60	82.38541	98.56771	82.63889	82.3809	99.82406	100	82.98172
12:32:46 PM	8.834274	63.42593	60	59.64699	60	82.88657	98.4809	81.65509	82.8795	100	100	82.97177
12:32:56 PM	8.74385	64.35185	60	60.72916	60	81.09772	98.3941	82.92824	81.1123	98.66152	100	82.96182
12:33:06 PM	8.608222	65.0463	60	61.49306	60	78.32236	98.30729	83.50694	77.78504	92.86958	100	82.9469
12:33:16 PM	8.608222	64.35185	60	60.79282	60	77.57774	98.26389	82.58102	77.60947	88.26708	100	82.9469
12:33:27 PM	8.653426	64.58333	60	60.28357	60	77.98399	98.30729	81.36574	77.98967	85.34407	100	82.95187
12:33:37 PM	8.653426	62.03704	60	58.31018	60	81.17572	98.30729	80.15046	81.14192	85.51304	100	82.95187
12:33:47 PM	8.698638	60.41667	1	30.10995	1	7.699266	98.35069	63.65741	6	0	23.63636	15
12:33:57 PM	8.789063	61.34259	1	5.63368	1	8.340212	98.4375	26.50463	7.834187	0	23.63636	15
12:34:07 PM	8.789063	55.6713	1	2.864583	1	6.224072	98.4375	11.28472	6.261363	0	23.63636	15
12:34:17 PM	8.608222	56.25	1	2.578125	1	6	98.26389	10.70602	6	0	23.63636	15
12:34:27 PM	8.020473	56.8287	1	2.482639	1	6	97.69965	10.9375	6	0	23.63636	15
12:34:37 PM	7.568359	62.03704	1	2.45081	1	6	97.30903	10.82176	6	0	23.63636	15
12:34:47 PM	7.297094	61.45833	1	2.546296	1	6	97.00521	10.87963	6	0	23.63636	15
12:34:57 PM	7.477935	67.36111	1	2.609954	1	6	97.17882	10.87963	6	0	23.63636	15
12:35:07 PM	7.749199	66.55093	1	2.641782	1	6	97.43923	10.87963	6	0	23.63636	15
12:35:17 PM	7.884844	65.74074	1	2.70544	1	6	97.56945	10.82176	6	0	23.63636	15
12:35:27 PM	7.884844	64.69907	1	2.769097	1	6	97.56945	10.87963	6	0	23.63636	15
12:35:37 PM	7.749199	63.19444	1	2.641782	1	6	97.43923	10.87963	6	0	23.63636	15
12:35:47 PM	7.523147	69.21296	1	2.70544	1	6	97.17882	10.87963	6	0	23.63636	15
12:35:57 PM	7.251874	67.82407	1	2.737268	1	6	96.9618	10.82176	6	0	23.63636	15
12:36:07 PM	6.980609	63.42593	1	2.70544	1	6	96.70139	10.82176	6	0	23.63636	15

12:36:17 PM	6.618921	63.19444	1	2.673611	1	6	96.35416	10.82176	6	0	23.63636	15
12:36:27 PM	6.302444	63.42593	1	2.832755	1	6	96.05035	10.82176	6	0	23.63636	15
12:36:37 PM	5.985967	61.9213	1	2.737268	1	6	95.74653	10.82176	6	0	23.63636	15
12:36:47 PM	5.533854	65.16204	1	2.673611	1	6	95.3125	10.82176	6	0	23.63636	15
12:36:57 PM	5.217377	60.87963	1	2.70544	1	6	95.00868	10.82176	6	0	23.63636	15
12:37:08 PM	4.946113	61.34259	1	2.737268	1	6	94.74827	10.87963	6	0	23.63636	15
12:37:18 PM	4.584424	63.31019	1	2.70544	1	6	94.40105	10.82176	6	0	23.63636	15
12:37:28 PM	4.267939	64.35185	1	2.70544	1	6	94.09722	10.87963	6	0	23.63636	15
12:37:38 PM	3.861038	64.00463	1	2.609954	1	6	93.7066	10.9375	6	0	23.63636	15
12:37:48 PM	3.589765	60.99537	1	2.769097	1	6	93.44617	10.87963	6	0	23.63636	15
12:37:58 PM	3.228076	61.9213	1	2.769097	1	6	93.09895	10.87963	6	0	23.63636	15
12:38:08 PM	2.911607	61.34259	1	2.769097	1	6	92.79514	10.87963	6	0	23.63636	15
12:38:18 PM	2.595123	65.39352	1	2.641782	1	6	92.49132	10.9375	6	0	23.63636	15
12:38:28 PM	2.233434	63.19444	1	2.769097	1	6	92.1441	10.87963	6	0	23.63636	15
12:38:38 PM	1.916957	63.19444	1	2.291667	1	6	91.84028	10.18519	6	0	23.63636	15
12:38:48 PM	1.60048	62.61574	1	2.228009	1	6	91.53646	9.895834	6	0	23.63636	15
12:38:58 PM	1.284003	61.9213	1	2.132523	1	6	91.23264	9.895834	6	0	23.63636	15
12:39:08 PM	1.057943	63.88889	1	2.196181	1	6	90.97222	9.837963	6	0	23.63636	15
12:56:13 PM	7.02583	61.68981	60	57.60996	60	82.77284	96.7448	79.51389	82.77284	96.84505	100	82.77284
12:56:23 PM	7.613571	60.64815	60	57.64178	60	82.83749	97.30903	81.01852	82.82755	98.14898	100	82.83749
12:56:33 PM	8.065684	60.76389	60	57.03704	60	82.88722	97.74306	80.72917	82.88722	99.96392	100	82.88722
12:56:43 PM	8.517797	60.18519	60	56.36863	60	82.93696	98.17709	81.13426	82.93696	100	100	82.93696
12:56:53 PM	8.698638	60.41667	60	56.97338	60	82.95686	98.35069	81.07639	82.95686	100	100	82.95686
12:57:03 PM	8.698638	61.34259	60	56.78241	60	82.95686	98.3941	81.94444	82.95686	100	100	82.95686
12:57:13 PM	8.517797	61.80556	60	58.05556	60	82.93696	98.17709	82.2338	82.93696	99.86541	100	82.93696
12:57:23 PM	8.291737	62.26852	60	57.3235	60	82.91209	97.96007	82.58102	82.91209	99.8229	100	82.91209
12:57:33 PM	8.020473	61.80556	60	56.94156	60	82.88226	97.69965	82.00231	82.88226	100	100	82.88226
12:57:43 PM	7.703995	62.26852	60	58.46933	60	82.84744	97.39584	82.87037	82.84744	99.87965	100	82.84744
12:57:53 PM	7.523147	63.88889	60	57.83275	60	82.82755	97.22222	81.88657	82.82755	100	100	82.82755
12:58:03 PM	7.297094	63.31019	60	58.21469	60	82.80268	97.00521	82.11806	82.80766	100	100	82.80268
12:58:13 PM	7.251874	62.15278	60	57.64178	60	82.79771	97.00521	82.58102	82.79771	99.93507	100	82.79771
12:58:23 PM	7.297094	63.0787	60	58.94676	60	82.80268	97.00521	82.75463	82.80268	99.92885	100	82.80268
12:58:33 PM	7.523147	62.61574	60	59.67882	60	82.53497	97.22222	83.04398	82.52855	99.60905	100	82.82755
12:58:43 PM	7.613571	64.12037	60	59.90162	60	82.41953	97.30903	82.58102	82.29152	99.42218	100	82.83749
12:58:53 PM	7.79442	64.46759	60	60.82465	60	81.53969	97.48264	82.29167	81.55618	99.27008	100	82.85738
12:59:03 PM	7.97526	64.35185	60	60.25174	60	81.63493	97.65625	82.40741	81.645	99.14702	100	82.87728
12:59:13 PM	8.246532	63.77315	60	60.02893	60	81.23151	97.96007	82.58102	80.85396	97.55978	100	82.90712
12:59:23 PM	8.563002	63.88889	60	59.96528	60	80.81657	98.22048	82.63889	80.81587	96.26736	100	82.94193
12:59:33 PM	8.879486	62.61574	60	61.04746	60	78.6963	98.52431	82.58102	78.71725	92.42129	100	82.97674
12:59:43 PM	9.195963	63.54167	60	60.12442	60	79.6497	98.87153	81.53935	79.77823	91.47019	100	83.01156
12:59:53 PM	9.422016	63.54167	60	59.64699	60	80.02357	99.04514	81.65509	79.8242	89.88717	100	83.03642
1:00:03 PM	9.648076	63.31019	60	61.01563	60	78.43575	99.26215	81.94444	78.45606	87.20365	100	83.06129
1:00:13 PM	9.919341	64.00463	60	59.83796	60	78.93787	99.52257	81.36574	78.93138	84.7173	100	83.09113
1:00:23 PM	10.10019	63.19444	60	59.36053	60	81.0199	99.73959	80.43981	81.19617	85.5772	100	83.11102
1:00:33 PM	10.32625	62.73148	60	59.51968	60	82.10892	99.9132	80.15046	82.09932	87.1069	100	83.13589
1:00:43 PM	10.41667	64.35185	60	58.85128	60	83.14584	100	79.91898	83.14584	91.17892	100	83.14584
1:00:53 PM	10.50709	61.34259	50	58.59665	50	70.48895	100.0868	80.15046	70.66087	84.64725	93.24187	78.46003
1:01:03 PM	10.55229	62.73148	50	51.75347	50	65.86757	100.1302	71.75926	65.61904	73.32401	93.30315	78.49213
1:01:13 PM	10.55229	62.15278	50	48.82523	50	68.38319	100.1302	69.03935	68.3597	72.11044	93.30315	78.49213
1:01:23 PM	10.55229	62.15278	50	48.06134	50	72.291	100.1302	69.50231	72.25223	74.23004	93.30315	78.49213
1:01:33 PM	10.32625	61.57407	50	49.52546	50	74.16519	99.9132	70.60185	73.87211	79.0867	92.99676	78.33163
1:01:43 PM	9.919341	61.22685	50	49.55729	50	74.45058	99.52257	72.4537	74.44173	80.34783	92.44521	78.04273
1:01:53 PM	9.467236	62.5	50	50.57581	50	72.34526	99.08855	72.8588	72.35677	79.42886	91.83241	77.72174
1:02:03 PM	8.924699	62.03704	50	50.06655	50	71.75654	98.56771	72.97454	71.75787	77.8736	91.09702	77.33653
1:02:13 PM	8.291737	63.31019	50	50.95775	50	69.68253	97.96007	73.14815	69.70168	74.29087	90.23907	76.88713
1:02:23 PM	7.839624	62.61574	50	49.07986	50	71.75981	97.52604	71.23843	71.74141	74.35716	89.62625	76.56613
1:02:33 PM	7.387518	61.57407	50	48.95255	50	73.57838	97.09202	71.23843	73.55744	76.64719	89.01345	76.24514
1:02:43 PM	7.02583	63.31019	50	49.36632	50	73.87674	96.7448	71.12269	73.86407	78.618	88.5232	75.98834
1:02:53 PM	6.799769	64.12037	50	50.06655	50	73.06499	96.52778	72.16435	73.06632	79.1358	88.21677	75.82784
1:03:03 PM	6.618921	63.77315	50	51.08507	50	70.88773	96.35416	71.81713	70.93114	78.68111	87.97164	75.69943
1:03:13 PM	6.573717	64.23611	50	50.25752	50	70.1533	96.26736	72.16435	69.18163	75.65904	87.91037	75.66734
1:03:23 PM	6.483292	64.00463	50	50.09838	50	68.85298	96.22396	71.99074	68.85495	72.39258	87.7878	75.60313
1:03:33 PM	6.483292	62.96296	50	49.39815	50	70.5722	96.22396	70.65972	70.56016	73.15689	87.7878	75.60313
1:03:43 PM	6.618921	62.96296	50	48.76157	50	73.62127	96.35416	69.90741	73.56499	77.30767	87.97164	75.69943
1:03:53 PM	6.664141	63.77315	40	45.10127	40	58.11291	96.39758	68.98148	58.21494	60.49791	60.49791	58.66527
1:04:03 PM	6.799769	62.15278	40	41.28183	40	56.93808	96.52778	61.9213	56.96372	59.91215	60.60981	58.73987
1:04:13 PM	6.754557	61.34259	40	38.99016	40	58.21788	96.52778	60.01157	58.10316	57.31724	60.57251	58.715
1:04:23 PM	6.664141	61.34259	40	38.73553	40	58.66527	96.39758	59.02778	58.66527	57.66088	60.49791	58.66527
1:04:33 PM	6.347656	61.57407	40	38.83102	40	58.49121	96.09375	59.66435	58.49121	56.79449	60.23682	58.49121
1:04:43 PM	5.805127	60.99537	40	37.20775	40	58.19283	95.57292	59.02778	58.19283	56.29136	59.78924	58.19283
1:04:53 PM	5.262589	62.15278	40	37.87616	40	57.89442	95.00868	58.96991	57.89442	55.80525	59.34164	57.89442
1:05:03 PM	4.584424	60.64815	40	36.63484	40	57.52144	94.40105	58.27546	57.52144	55.05271	58.78216	57.52144
1:05:13 PM	3.861038	62.61574	40	36.76215	40	57.12357	93.7066	58.27546	57.12357	54.11464	58.18536	57.12357
1:05:23 PM	3.13766	63.31019	40	35.489	40	56.72571	93.05556	57.40741	56.72571	53.86829	57.58857	56.72571
1:05:33 PM	2.549911	62.61574	40	36.85764	40	56.40245	92.44791	57.2338	56.40245	53.48938	57.10368	56.40245
1:05:43 PM	1.962169	62.84722	40	36.98495	40	56.07919	91.88368	57.34954	56.07919	52.74755	56.61878	56.07919
1:05:53 PM	1.60048	63.54167	40	36.12558	40	60.96029	91.44965	56.77083	60.96029	59.48693	63.94043	60.96029
1:06:03 PM	1.193579	61.80556	40	36.6985	40	60.71615	91.14584	58.33333	60.71615	61.42511	63.57422	60.71615
1:06:13 PM	1.012731	63.19444	40	38.44907	40	60.60764	90.97222	59.25926	60.60764	62.22351	63.41146	60.60764
1:06:23 PM	0.9675184	63.19444	40	39.49942	40	60.51309	90.92882	59.89583	60.50307	62.23844	63.37077	60.58052
1:06:33 PM	0.9223143	63.0787	40	39.78588	40	60.36286	90.88542	59.9537	60.35857	62.23642	63.33009	60.55339
1:06:43 PM	1.012731	63.19444	40	39.84954	40	60.31019	90.97222	60.30093	60.30718	62.34129	63.41146	60.60764
1:06:53 PM	1.148359	63.54167	40	39.46759	40	60.68902	91.14584	59.83796	60.36905	62.34442	63.53353	60.68902
1:07:03 PM	1.329207	63.0787	40	39.91319	40	60.38725	91.27604	60.01157	60.38552	62.47759	63.69629	60.79752
1:07:13 PM	1.645684	62.84722	40	39.11748	40	60.98741	91.57986	59.60648	60.98741	63.24643	63.98112	60.98741
1:07:23 PM	1.826533	62.73148	30	38.22627	30	44.56179	91.75347	59.83796	44.72631	47.95531	56.50688	56.00459
1:07:33 PM	2.052593	63.31019	30	32.24248	30	42.9494	91.97049	51.44676	42.99425	40.22699	56.69339	56.12893

1:07:43 PM	2.188221	61.45833	30	27.88194	30	48.68676	92.10069	47.62732	48.6444	42.43999	56.80529	56.20353
1:07:53 PM	2.143017	62.61574	30	28.00926	30	51.73444	92.0573	47.62732	51.69463	46.0579	56.768	56.17867
1:08:03 PM	2.007373	61.57407	30	29.8235	30	52.31219	91.92708	49.30555	52.30866	49.74171	56.65607	56.10405
1:08:13 PM	1.781328	61.34259	30	30.84201	30	50.50872	91.71008	51.44676	50.52556	49.05353	56.46959	55.97972
1:08:23 PM	1.284003	60.87963	30	31.1603	30	48.39599	91.23264	50.92593	48.4192	46.4632	56.0593	55.7062
1:08:33 PM	0.9223143	61.11111	30	30.07813	30	48.46034	90.88542	51.04167	48.4619	43.83715	55.76092	55.50728
1:08:43 PM	0.379777	62.26852	30	29.34606	30	49.98328	90.36459	49.59491	49.97021	44.22635	55.31332	55.20888
1:08:53 PM	0	62.26852	30	29.47338	30	50.87773	89.84375	49.53704	50.8672	45.0524	55	55
1:09:03 PM	0	62.61574	30	28.93229	30	52.98933	89.49653	49.30555	52.96798	48.86642	55	55
1:09:13 PM	0	62.03704	30	30.2691	30	51.90693	89.0625	51.04167	51.15606	49.40845	55	55
1:09:23 PM	0	63.19444	30	29.88715	30	50.53152	88.75867	51.09954	50.52926	48.86391	55	55
1:09:33 PM	0	62.73148	30	31.12847	30	47.64284	88.54167	50.81019	47.66541	45.39318	55	55
1:09:43 PM	0	62.73148	20	24.5081	20	34.40591	88.41145	47.51157	33.23566	27.76971	42.8	43
1:09:53 PM	0	63.54167	20	20.91146	20	34.06052	88.41145	39.0625	34.07874	26.10302	42.8	43
1:10:03 PM	0	62.84722	20	19.19271	20	35.74113	88.41145	37.38426	35.72498	24.7605	42.8	43
1:10:13 PM	0	62.61574	20	19.03356	20	37.78149	88.49826	36.9213	37.35253	25.27789	42.8	43
1:10:23 PM	0	62.03704	20	18.11053	20	40.90693	88.41145	36.5162	40.86913	29.5887	42.8	43
1:10:33 PM	0	62.03704	20	19.38368	20	40.62602	88.23785	38.02084	40.6137	31.25603	42.8	43
1:10:43 PM	0	61.9213	20	19.9566	20	40.25218	88.10764	38.59954	40.06225	32.22688	42.8	43
1:10:53 PM	0	61.34259	20	20.37037	20	39.37345	87.80382	39.0625	39.38086	32.44289	42.8	43
1:11:03 PM	0	61.34259	20	20.30671	20	38.8845	87.5868	39.00463	38.89064	32.45509	42.8	43
1:11:13 PM	0	60.76389	20	20.68866	20	37.64452	87.19618	39.17824	37.65829	31.33176	42.8	43
1:11:23 PM	0	61.9213	10	20.33854	10	26.08951	86.89236	39.35185	25.98118	22.05507	40.2	30
1:11:33 PM	0	60.99537	10	13.27257	10	22.79049	86.58854	31.25	22.85594	12.60908	40.2	30
1:11:43 PM	0	61.11111	10	9.293982	10	26.21523	86.37153	30.09259	26.20111	10.96602	40.2	30
1:11:53 PM	0	62.26852	10	9.166667	10	26.61587	86.02431	27.77778	26.69373	9.987725	40.2	30
1:12:03 PM	0	61.80556	10	9.771412	10	26.51023	85.67709	27.5463	26.50565	8.71184	40.2	30
1:12:13 PM	0	61.9213	10	9.644097	10	27.09425	85.28646	27.25694	27.08714	8.5174	40.2	30
1:12:23 PM	0	61.45833	10	10.05787	10	26.67351	84.85243	27.48843	26.67466	7.934196	40.2	30
1:12:33 PM	0	61.9213	10	10.28067	10	26.6174	84.4184	28.125	26.62302	7.236065	40.2	30
1:12:43 PM	0	62.03704	10	9.739583	10	27.51488	83.98438	27.31482	27.50968	7.673106	40.2	30
1:12:53 PM	0	62.61574	10	10.15336	10	27.19859	83.59375	27.1412	27.20166	7.799506	40.2	30
1:13:03 PM	0	61.80556	1	9.644097	1	13.27729	83.24653	27.1412	13.45017	0	23.63636	15
1:13:13 PM	0	61.80556	1	1.71875	1	13.34104	82.98611	12.38426	13.35542	3.791657	23.63636	15
1:13:23 PM	0	62.73148	1	1.241319	1	13.02699	82.7691	8.564815	13.03181	9.183685	23.63636	15
1:13:34 PM	0	61.45833	1	1.400463	1	12.13907	82.50868	9.027778	12.14708	13.1169	23.63636	15
1:13:44 PM	0	59.72222	1	1.623264	1	10.92517	82.37847	9.606482	10.93763	14.02226	23.63636	15
1:13:54 PM	0	59.60648	1	1.814236	1	9.34025	82.16146	10.06944	9.451065	13.65976	23.63636	15
1:14:04 PM	0	58.68056	1	1.846065	1	7.690348	82.16146	10.47454	7.724191	10.93945	23.63636	15
1:14:14 PM	0	60.18519	1	1.559606	1	6.240122	81.98785	10.3588	6.251314	6.066057	23.63636	15
1:14:24 PM	0	62.03704	1	1.336806	1	5.636366	81.94444	8.912037	5.643103	5	23.63636	15
1:14:34 PM	0	61.11111	1	1.145833	1	5.352234	81.90104	8.622685	5.355151	5	23.63636	15
1:14:44 PM	0	64.69907	1	1.145833	1	5.011181	81.85764	8.564815	5.014097	5	23.63636	15
1:14:54 PM	0	64.00463	30	1.145833	3.039738	34.0659	81.81423	8.564815	34.0659	55	55	55
1:15:04 PM	0	62.15278	30	20.11574	18.4456	34.0659	81.77084	35.76389	34.0659	55	55	55
1:15:14 PM	0	63.42593	30	33.4838	30	32.61204	81.68403	53.35648	32.68171	45.17913	55	55
1:15:24 PM	0	64.81481	30	26.99074	30	40.4283	81.81423	46.64352	40.36811	37.40599	55	55
1:15:34 PM	0	65.97222	30	26.92708	30	46.64022	82.07465	44.56018	46.57876	40.10227	55	55
1:15:44 PM	0	66.78241	30	29.09144	30	49.73946	82.6823	45.48611	49.7213	46.26505	55	55
1:15:54 PM	0	67.36111	30	30.61922	30	47.87054	83.50695	47.4537	47.88293	45.94392	55	55
1:16:04 PM	0	67.59259	30	31.41493	30	44.1936	84.46181	47.4537	43.24508	42.06697	55	55
1:16:14 PM	0	67.70833	30	30.10995	30	43.09879	85.67709	45.65972	43.10098	38.3238	55	55
1:16:25 PM	0	67.70833	30	29.75984	30	44.11287	87.19618	45.02315	44.10807	38.01834	55	55
1:16:35 PM	0	65.27778	30	29.37789	30	45.38133	88.75867	44.7338	45.30588	38.24691	55	55
1:16:45 PM	0.1989285	63.31019	30	29.37789	30	46.96473	90.19097	45.08102	46.95229	40.08303	52.9332	53.10543
1:16:55 PM	1.736108	61.11111	30	29.50521	30	49.94493	91.66666	45.8912	49.92514	46.18945	53.82197	53.92014
1:17:05 PM	3.047236	59.25926	30	30.65104	30	49.13781	92.92535	48.72685	49.15084	46.21413	54.58004	54.61503
1:17:15 PM	3.815826	59.02778	30	29.79167	30	50.89085	93.66319	48.72685	50.88669	48.7841	55.03358	55.02239
1:17:25 PM	4.313151	58.56481	30	29.88715	30	51.38938	94.14063	50.81019	51.38712	48.96228	55.42896	55.28597
1:17:35 PM	4.267939	57.75463	30	29.88715	30	52.04956	94.09722	51.15741	52.04731	49.7863	55.39301	55.262
1:17:45 PM	3.90625	58.56481	30	29.15509	30	53.48704	93.7066	51.21528	52.77691	51.18535	55.10547	55.07031
1:17:55 PM	3.13766	59.14352	30	30.96933	30	51.06351	93.01215	52.25694	51.0829	50.24849	54.63232	54.66296
1:18:05 PM	2.097797	60.53241	30	30.58739	30	50.65141	92.01389	52.60417	50.66316	48.91756	54.03109	54.11183
1:18:15 PM	1.148359	61.9213	30	30.42824	30	49.75104	91.10242	52.48843	48.78278	45.77608	56.0119	53.60863
1:18:25 PM	0.1085043	61.11111	30	30.30092	30	49.12836	90.10416	51.5625	49.13438	43.69226	48.70351	53.05751
1:18:35 PM	0	62.26852	30	29.85533	30	50.29276	89.36633	50.11574	50.28987	44.36639	48.6	53
1:18:45 PM	0	62.84722	30	29.95081	30	51.2531	88.67188	50.34722	51.25211	45.31035	48.6	53
1:18:55 PM	0	63.42593	30	29.75984	30	51.94736	88.15104	49.88426	51.40689	46.80923	48.6	53
1:19:05 PM	0	63.88889	30	30.33275	30	51.05512	87.84722	49.88426	51.06178	47.8405	48.6	53
1:19:15 PM	0	63.77315	30	30.14178	30	50.60831	87.71702	50.23148	50.61114	47.96514	48.6	53
1:19:25 PM	0	63.77315	60	32.97454	36.57176	80.12674	87.67361	50.34722	80.12674	100	100	85
1:19:35 PM	0	63.77315	60	53.98148	54.14295	80.12674	87.76041	74.53704	80.12674	100	100	85
1:19:45 PM	0	65.0463	60	57.9919	60	83.06447	87.97743	82.75463	82.98415	99.81735	100	85
1:19:55 PM	0	65.74074	60	60.69734	60	81.03806	88.36806	82.87037	81.052	98.46237	100	85
1:20:05 PM	0	67.36111	60	62.5434	60	76.69644	89.1059	82.40741	76.6843	93.04665	100	85
1:20:15 PM	0.2441406	67.59259	60	62.09781	60	71.53145	90.23438	81.53935	71.57341	80.30635	100	85.0293
1:20:25 PM	1.871745	66.08796	60	57.9919	60	76.16997	91.79688	75.92593	76.12981	81.39323	100	85.22461
1:20:35 PM	3.499349	63.88889	60	57.38715	60	79.92405	93.44617	75.23148	78.65364	84.56795	100	85.43077
1:20:45 PM	5.443438	63.54167	60	58.85128	60	81.23615	95.2257	77.37269	81.21317	89.20989	100	85.65321
1:20:55 PM	7.20667	60.76389	60	59.93344	60	81.47371	96.9184	78.76157	81.47237	91.8145	100	85.86481
1:21:07 PM	8.834274	59.9537	60	58.8831	60	85.31441	98.4809	79.22454	85.29208	99.70552	100	86.06012
1:21:17 PM	9.919341	59.83796	60	59.77431	60	85.75032	99.52257	80.84491	85.7458	100	100	86.19032
1:21:27 PM	10.50709	60.18519	25	43.50984	25	10.87998	100.0868	76.27315	11.25018	5.283067	47.68356	52.49086
1:21:37 PM	10.82357	50	25	20.14757	25	28.48438	100.3906	38.31018	28.38733	9.800371	47.95415	52.6412
1:21:47 PM	10.9592	62.5	25	18.17419	25	49.28722	100.5208	35.06945	49.1507	32.96219	48.07012	52.70562
1:21:57 PM	10.73314	62.84722	25	24.9537	25	49.66942	100.3038	42.7662	49.6685	42.09333	47.87684	52.59824
1:22:07 PM	10.00977	60.76389	25	26.13137	25	47.16424	99.47916	46.00695	47.18687	42.66173	47.14238	52.19021