If the adjusted performance estimate is worse than originally predicted, the client shall be given the same cooling off period and cancellation rights (to include any right to cancel without financial penalties) that applied to the original quote. This shall apply from the date of issue of the updated performance estimate.

### 3.7.2 Standard Estimation Method

The approach is as follows:

1. Establish the electrical rating of the PV array in kilowatts peak (kWp)
2. Determine the postcode region
3. Determine the array pitch
4. Determine the array orientation
5. Look up kWh/kWp (Kk) from the appropriate location specific table
6. Determine the shading factor of the array (SF) according to any objects blocking the horizon - using shade factor procedure set out in 3.7.7

The estimated annual electricity generated (AC) in kWh/year of installed system shall then be determined using the following formula:

**Annual AC output (kWh) = kWp x Kk x SF**

### 3.7.3 kWp of Array (kWp)

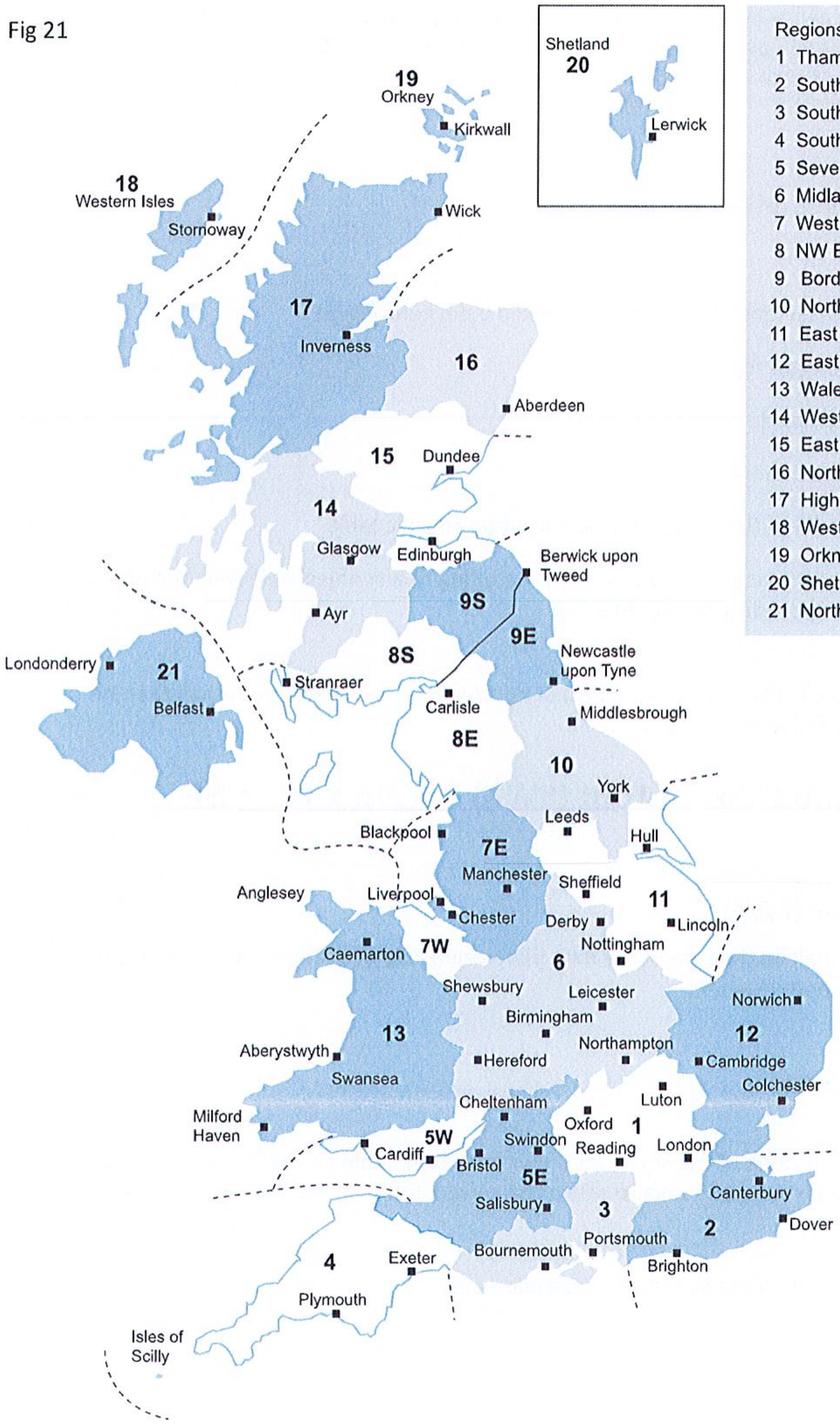
The kWp value used shall be the sum of the data plate value (Wp at STC) of all modules installed (the value printed on the module label).

### 3.7.4 Postcode Zone

Determine the postcode zone of the site from the map and the table on the following pages. Once this has been obtained, you will be able to select the correct table for the kWh/kWp (Kk) values to be selected.

*Note: These zones are the same as the SAP postcode zones*

Fig 21




Regions
1 Thames
2 South East England
3 Southern England
4 South West England
5 Severn
6 Midlands
7 West Pennines
8 NW England/ SW Scotland
9 Borders
10 North East England
11 East Pennines
12 East Anglia
13 Wales
14 West Scotland
15 East Scotland
16 North East Scotland
17 Highland
18 Western Isles
19 Orkney
20 Shetland
21 Northern Ireland

| Postcode | Zone | Postcode | Zone | Postcode | Zone | Postcode | Zone |
|---|---|---|---|---|---|---|---|
| AB | 16 | G | 14 | N | 1 | SK | 7E |
| AL | 1 | GL | 5E | NE | 9E | SK13 | 6 |
| B | 6 | GU | 1 | NG | 11 | SK17 | 6 |
| BA | 5E | GU11-12 | 3 | NN | 6 | SK22-23 | 6 |
| BB | 7E | GU14 | 3 | NP | 5W | SL | 1 |
| BD | 11 | GU28-29 | 2 | NPS | 13 | SM | 1 |
| BD23-24 | 10 | GU30-35 | 3 | NR | 12 | SN | 5E |
| BH | 3 | GU46 | 3 | NW | 1 | SN7 | 1 |
| BL | 7E | GU51-52 | 3 | OL | 7E | SO | 3 |
| BN | 2 | HA | 1 | OX | 1 | SP | 5E |
| BR | 2 | HD | 11 | PA | 14 | SP6-11 | 3 |
| BS | 5E | HG | 10 | PE | 12 | SR | 9E |
| BT | 21 | HP | 1 | PE9-12 | 11 | SR7-8 | 10 |
| CA | 8E | HR | 6 | PE20-25 | 11 | SS | 12 |
| CB | 12 | HS | 18 | PH | 15 | ST | 6 |
| CF | 5W | HU | 11 | PH19-25 | 17 | SW | 1 |
| CH | 7E | HX | 11 | PH26 | 16 | SY | 6 |
| CH5-8 | 7W | IG | 12 | PH30-44 | 17 | SY14 | 7E |
| CM | 12 | IP | 12 | PH49 | 14 | SY15-25 | 13 |
| CM21-23 | 1 | IV | 17 | PH50 | 14 | TA | 5E |
| CO | 12 | IV30-32 | 16 | PL | 4 | TD | 9S |
| CR | 1 | IV36 | 16 | PO | 3 | TD12 | 9E |
| CT | 2 | KA | 14 | PO18-22 | 2 | TD15 | 9E |
| CV | 6 | KT | 1 | PR | 7E | TF | 6 |
| CW | 7E | KW | 17 | RG | 1 | TN | 2 |
| DA | 2 | KW15-17 | 19 | RG21-29 | 3 | TQ | 4 |
| DD | 15 | KY | 15 | RH | 1 | TR | 4 |
| DE | 6 | L | 7E | RH10-20 | 2 | TS | 10 |
| DG | 8S | LA | 7E | RH77 | 2 | TW | 1 |
| DH | 10 | LA7-23 | 8E | RM | 12 | UB | 1 |
| DH4-5 | 9E | LD | 13 | S | 11 | W | 1 |
| DL | 10 | LE | 6 | S18 | 6 | WA | 7E |
| DN | 11 | LL | 7W | S32-33 | 6 | WC | 1 |
| DT | 3 | LL23-27 | 13 | S40-45 | 6 | WD | 1 |
| DY | 6 | LL30-78 | 13 | S49 | 6 | WF | 11 |
| E | 1 | LN | 11 | SA | 5W | WN | 7E |
| EC | 1 | LS | 11 | SA14-20 | 13 | WR | 6 |
| EH | 15 | LS24 | 10 | SA31-48 | 13 | WS | 6 |
| EH43-46 | 9S | LU | 1 | SA61-73 | 13 | WV | 6 |
| EN | 1 | M | 7E | SE | 1 | YO | 10 |
| EN9 | 12 | ME | 2 | SG | 1 | YO15-16 | 11 |
| EX | 4 | MK | 1 | | | YO25 | 11 |
| FK | 14 | ML | 14 | | | ZE | 20 |
| FY | 7E | | | | | | |

### 3.7.5 Orientation

The orientation of the array is to be measured or determined from plan. The required value is the azimuth angle of the PV modules relative to due South. Hence, an array facing due south has an azimuth value of 0°; an array facing either SW or SE has an azimuth value of 45°; and an array facing either East or West has an azimuth value of 90°.

The azimuth value is to be rounded to the nearest 5°.

### 3.7.6 Inclination

The Inclination (or pitch) of the array is to be measured or determined from plan. The required value is the degrees from horizontal. Hence, an inclination of 0° represents a horizontal array; 90° represents a vertical array.

The inclination value is to be rounded to the nearest 1°.

### 3.7.6.1 kWh/kWp Value (Kk)

Tables of kWh/kWp (Kk) values are provided for each postcode zone. Abbreviated tables are contained in Annex D of this document. Full tables are available to download from the MCS website.

The tables provide kWh/kWp values for the zone in question for 1° variations of inclination (p[itch) and 5° variations of orientation.

*Note: This data has been provided by the European Commission, Joint Research Centre. The data is drawn from the Climate-SAF-PVGIS dataset and multiplied by 0.8*

### 3.7.7 Shade Factor (SF)

Where there is a potential for shading from objects further than 10m away from the centre midpoint of the array then the procedure given in 3.7.7.1 shall be applied, where there are objects at or less than 10m away from the centre midpoint of the array then the procedure stated in clause 3.7.7.2 shall be used **in addition** to the method in clause 3.7.7.1.

### 3.7.7.1 Determining shading factor as a result of objects further than 10m from the centre and midpoint of the array

Where there is an obvious clear horizon and no near or far shading, the assessment of SF can be omitted and an SF value of 1 used in all related calculations.

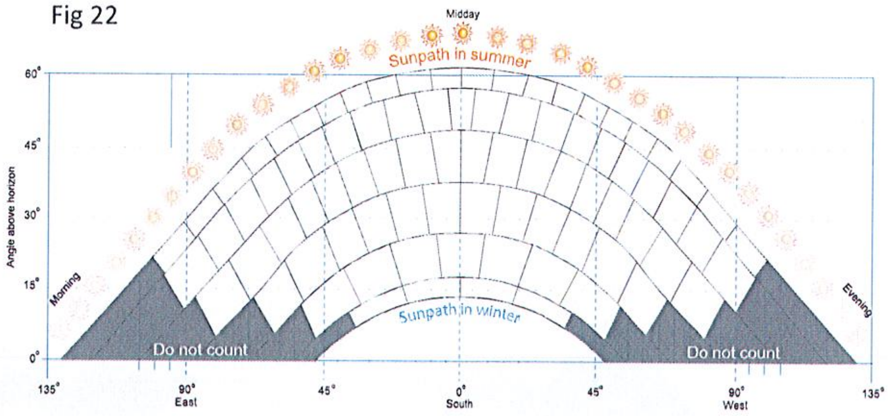
Where there is potential for shading, it shall always be analysed and the reading shall be taken from a location that represents the section of the potential array that is most affected by any shade. For systems with near shading this will typically be just to the North of the near shading object.

It is intended that this assessment provides an indicative estimate of the potential shading on the solar array. This is done by indicating how much of the potential irradiance could be blocked by objects on the horizon at differing times of the day and of the year (as indicated by the different arcs).

The sunpath diagram below shall be used to produce a shading analysis for all estimates produced.

Fig 22

The diagram shown has a total of 84 segments, each segment has a value of 0.01



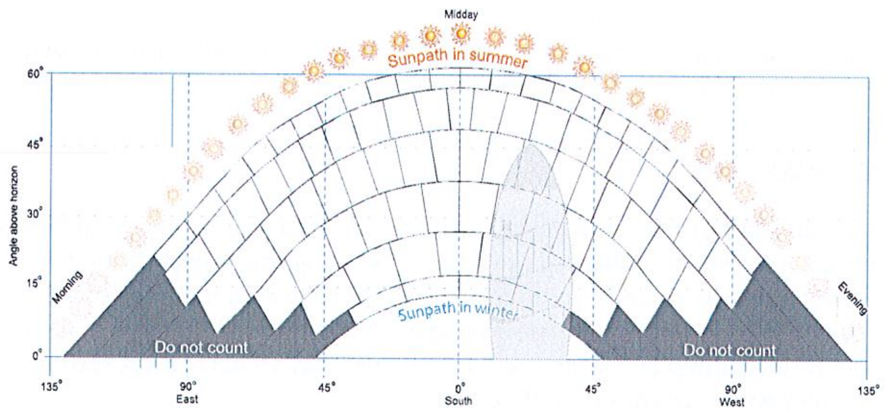

The potential shading is analysed as follows:

Stand as near as possible to the base and centre of the proposed array, e.g. through an upstairs window, unless there is shading from objects within 10m (e.g. aerials, chimneys, etc.), in which case the assessment of shading must be taken from a position more representative of the centre and base of the potentially affected array position.

Looking due south (irrespective of the orientation of the array), draw a line showing the uppermost edge of any objects that are visible on the horizon (either near or far) onto the sunpath diagram

Fig 23

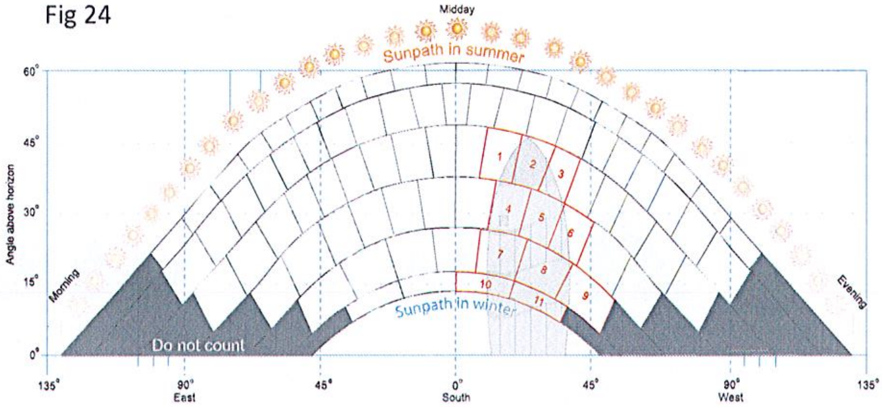
This line is called the *horizon line*, an example of which is shown here:




*Note: There are purpose made instruments for undertaking sunpath assessments; the use of such instruments is optional*

Once the horizon line has been drawn, the number of segments that have been touched by the line, or that fall **under** the horizon line shall be counted, in the following example you can see there are 11 segments covered or touched by the horizon line.

Fig 24




The total number of segments are multiplied by their value (0.01) and the total value shall be deducted from 1 to arrive at the shading factor.

The result will be the shading factor for the proposed installation, in our example the shading factor is calculated as follows:

**1 - (11*0.01) = 1 – 0.11 = <u>0.89</u>**

For systems connected to multiple inverters, or a single inverter with more than one MPP, it is acceptable to do a separate calculation of SF for each sub array (each array connected to a dedicated MPP tracker.

*Note: installing a system will any significant near shading will have a considerable effect on array performance. Where possible any near shading on the array should be avoided.*

**IMPORTANT NOTE**

**This shade assessment procedure has been designed to provide a simplified and standardised approach for MCS installers to use when estimating the impact of shade on system performance. It is not intended to be as accurate as more sophisticated methods such as, for example, those included in proprietary software packages. It is estimated that this shade assessment method will yield results within 10% of the actual annual energy yield for most systems. Unusual systems or environments may produce different results.**

Where the shading factor is less than 1 (i.e. any shading is present) the following disclaimer shall accompany the quotation:

"This shade assessment has been undertaken using the standard MCS procedure - it is estimated that this method will yield results within 10% of the actual annual energy yield for most systems."

## 3.7.7.2 Determining shading factor as a result of objects at, or less than, 10m from the centre midpoint of the array

As noted previously, shading from objects adjacent to the array (for example: vent pipes, chimneys, and satellite dishes) can have a very significant impact on the system performance. Where such shading is apparent, either the array should be repositioned out of the shade zone, or where possible the object casting the shade should be relocated. Where some near shade remains, the following additional shade analysis procedure shall be undertaken in addition to the method described in 3.7.7.1:

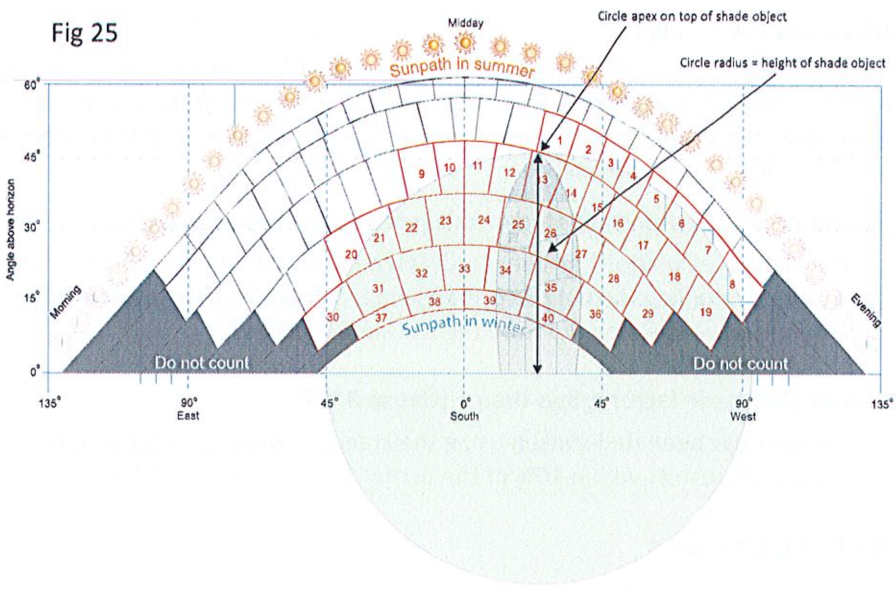
a. A standard horizon line, as described previously, shall be drawn - to represent the worst case (drawn from the array location most affected by shade)

b. In addition, any objects on the horizon diagram that are 10m or closer to any part of the array, shall have a shade circle added to the diagram to reflect the severe impact that these items may have on the array performance. Where there are multiple objects within 10m, then multiple circles shall be drawn – one for each object.

The shade circle shall have a radius equal to the height of the object. The shade circle should be located so that the apex of the circle sits on the highest point of the shade object.

All segments touched by or within the shade circle should be counted as part of the overall shade analysis.

Fig 25




*Note: The above diagram uses the same shade object as the worked example in section 3.7.7. Assuming the object is near shade results in a shade factor of 0.6 (compared with 0.89 in the previous calculation).*

### 3.7.8 Documentation

For systems under the MCS scheme, a performance estimate that determines the total annual a.c. energy output of a given system shall be communicated with the client before the point that the contract is awarded.

Along with the performance estimate, the client shall be provided with the sun path diagram and the information used to calculate the performance estimate as illustrated in the following table.

| | |
|---|---|
| **A. Installation data** | |
| Installed capacity of PV system - kWp (stc) | kWp |
| Orientation of the PV system – degrees from South | ° |
| Inclination of system – degrees from horizontal | ° |
| Postcode region | |
| **B. Calculations** | |
| kWh/kWp (Kk) from table | kWh/kWp |
| Shade factor (SF) | |
| Estimated annual output (kWp x Kk x SF) | kWh |

All quotations and / or estimates to customers shall be accompanied by one or more of the following disclaimers where applicable:

<u>For all quotations and / or estimates:</u>

*"The performance of solar PV systems is impossible to predict with certainty due to the variability in the amount of solar radiation (sunlight) from location to location and from year to year. This estimate is based upon the standard MCS procedure is given as guidance only. It should not be considered as a guarantee of performance."*

**Additionally where data has been estimated or taken remotely (clause 3.7.1):**

"This system performance calculation has been undertaken using estimated values for array orientation, inclination or shading. Actual performance may be significantly lower or higher if the characteristics of the installed system vary from the estimated values."

**Additionally where the shade factor is less than 1 (clause 3.7.7):**

"This shade assessment has been undertaken using the standard MCS procedure - it is estimated that this method will yield results within 10% of the actual annual energy yield for most systems."

### 3.7.9 Additional Estimates

Additional estimates may be provided using an alternative methodology, including proprietary software packages, but any such estimates must clearly describe and justify the approach taken and factors used and must not be given greater prominence than the standard MCS estimate. In addition, it must be accompanied by a warning stating that it should be treated with caution if it is significantly greater than the result given by the standard method.

# 4 INSTALLATION/SITEWORK

## 4.1 General

Standard health and safety practice and conventional electrical installation practice must apply to the installation of a PV system. Issues such as working on roofs or standard domestic a.c. wiring are covered thoroughly in other publications and are not detailed in this guide. Attention shall be paid to the location of accessories and equipment to ensure that any future service and maintenance can be carried out.

## 4.2 PV Specific Hazards

When compiling a method statement and risk assessment for the installation of a PV system, there are a number of PV specific hazards that need to be addressed. These will be in addition to standard considerations such as PPE (Personal Protective Equipment), working at height, manual handling, handling glass and the application of the construction design and management (CDM) regulations.

- PV modules produce electricity when exposed to daylight and individual modules cannot be switched off. Therefore unlike most other electrical installation work, the installation of a PV system typically involves working on a live system. See requirements of Regulation 14 of Electricity at Work Regulations 1989.
- As current limiting devices, PV module string circuits cannot rely on fuse protection for automatic disconnection of supply under fault conditions, as the short-circuit current is little more than the operating current. Once established, a fault may remain a hazard, perhaps undetected, for a considerable time.
- Good wiring design and installation practice will serve to protect both the system installers and any persons subsequently coming into contact with the system from an electric shock hazard (operator, owner, cleaner, service engineers, etc).
- Undetected, fault currents can also develop into a fire hazard. Without fuse protection to clear such faults, protection from this fire hazard can be achieved only by both a good d.c. system design and a careful installation.
- PV presents a unique combination of hazards – due to risk of shock, falling, and simultaneous manual handling difficulty. All of these hazards are encountered as a matter of course on a building site, but rarely all at once. While roofers may be accustomed to minimising risks of falling or injury due to manual handling problems, they may not be used to dealing with the risk of electric shock. Similarly, electricians would be familiar with electric shock hazards but will not be used to handling large objects at heights.

**Zone 1**

| Inclination (variation from horizontal) | Orientation (variation from south) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| 0 | 828 | 828 | 828 | 828 | 828 | 828 | 828 | 828 | 828 | 828 |
| 1 | 835 | 835 | 835 | 835 | 835 | 835 | 834 | 834 | 833 | 833 |
| 2 | 843 | 843 | 843 | 842 | 842 | 841 | 841 | 840 | 839 | 838 |
| 3 | 850 | 850 | 850 | 849 | 849 | 848 | 847 | 846 | 845 | 843 |
| 4 | 857 | 857 | 857 | 856 | 855 | 854 | 853 | 852 | 850 | 848 |
| 5 | 864 | 864 | 864 | 863 | 862 | 861 | 859 | 857 | 855 | 853 |
| 6 | 871 | 871 | 870 | 869 | 868 | 867 | 865 | 863 | 861 | 858 |
| 7 | 878 | 877 | 877 | 876 | 874 | 873 | 871 | 868 | 866 | 862 |
| 8 | 884 | 884 | 883 | 882 | 880 | 879 | 876 | 873 | 870 | 867 |
| 9 | 890 | 890 | 889 | 888 | 886 | 884 | 882 | 878 | 875 | 871 |
| 10 | 896 | 896 | 895 | 894 | 892 | 890 | 887 | 883 | 880 | 875 |
| 11 | 902 | 902 | 901 | 900 | 898 | 895 | 892 | 888 | 884 | 879 |
| 12 | 908 | 908 | 907 | 905 | 903 | 900 | 897 | 893 | 888 | 883 |
| 13 | 914 | 913 | 912 | 910 | 908 | 905 | 901 | 897 | 892 | 887 |
| 14 | 919 | 919 | 917 | 916 | 913 | 910 | 906 | 901 | 896 | 890 |
| 15 | 924 | 924 | 922 | 920 | 918 | 914 | 910 | 905 | 900 | 894 |
| 16 | 929 | 929 | 927 | 925 | 922 | 919 | 914 | 909 | 903 | 897 |
| 17 | 934 | 933 | 932 | 930 | 927 | 923 | 918 | 913 | 907 | 900 |
| 18 | 938 | 938 | 936 | 934 | 931 | 927 | 922 | 917 | 910 | 903 |
| 19 | 943 | 942 | 941 | 938 | 935 | 931 | 926 | 920 | 913 | 906 |
| 20 | 947 | 946 | 945 | 942 | 939 | 935 | 929 | 923 | 916 | 908 |
| 21 | 951 | 950 | 949 | 946 | 943 | 938 | 933 | 926 | 919 | 911 |
| 22 | 954 | 954 | 952 | 950 | 946 | 941 | 936 | 929 | 922 | 913 |
| 23 | 958 | 957 | 956 | 953 | 949 | 944 | 939 | 932 | 924 | 915 |
| 24 | 961 | 961 | 959 | 956 | 952 | 947 | 941 | 934 | 926 | 917 |
| 25 | 964 | 964 | 962 | 959 | 955 | 950 | 944 | 937 | 928 | 919 |
| 26 | 967 | 967 | 965 | 962 | 958 | 953 | 946 | 939 | 930 | 921 |
| 27 | 970 | 969 | 968 | 965 | 960 | 955 | 948 | 941 | 932 | 922 |
| 28 | 972 | 972 | 970 | 967 | 962 | 957 | 950 | 942 | 933 | 923 |
| 29 | 975 | 974 | 972 | 969 | 964 | 959 | 952 | 944 | 935 | 924 |
| 30 | 977 | 976 | 974 | 971 | 966 | 960 | 953 | 945 | 936 | 925 |
| 31 | 979 | 978 | 976 | 973 | 968 | 962 | 955 | 946 | 937 | 926 |
| 32 | 980 | 979 | 977 | 974 | 969 | 963 | 956 | 947 | 937 | 926 |
| 33 | 982 | 981 | 979 | 975 | 970 | 964 | 957 | 948 | 938 | 927 |
| 34 | 983 | 982 | 980 | 976 | 971 | 965 | 957 | 948 | 938 | 927 |
| 35 | 984 | 983 | 981 | 977 | 972 | 966 | 958 | 949 | 938 | 927 |
| 36 | 984 | 984 | 981 | 978 | 973 | 966 | 958 | 949 | 938 | 927 |
| 37 | 985 | 984 | 982 | 978 | 973 | 966 | 958 | 949 | 938 | 926 |
| 38 | 985 | 984 | 982 | 978 | 973 | 966 | 958 | 949 | 938 | 925 |
| 39 | 985 | 984 | 982 | 978 | 973 | 966 | 958 | 948 | 937 | 925 |
| 40 | 985 | 984 | 982 | 978 | 973 | 966 | 957 | 947 | 936 | 924 |
| 41 | 984 | 984 | 981 | 977 | 972 | 965 | 956 | 946 | 935 | 922 |
| 42 | 984 | 983 | 981 | 977 | 971 | 964 | 955 | 945 | 934 | 921 |
| 43 | 983 | 982 | 980 | 976 | 970 | 963 | 954 | 944 | 932 | 919 |
| 44 | 982 | 981 | 979 | 975 | 969 | 962 | 953 | 943 | 931 | 918 |
| 45 | 980 | 980 | 977 | 973 | 967 | 960 | 951 | 941 | 929 | 916 |