What information is available from a Utility Meter?

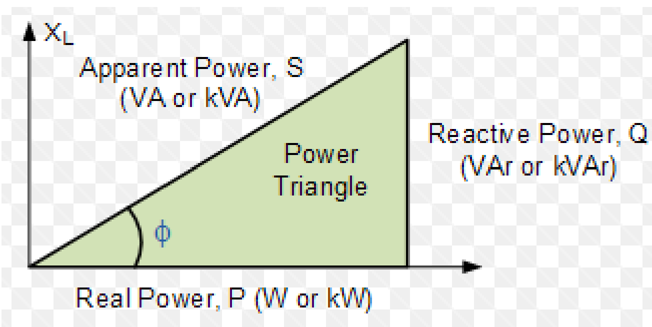
The data from a utility meter is generally 365 days of readings averaged over half hour intervals. The file is in a .CSV format which can be opened as an excel file and needs to be saved as an excel file. The data is kWH and kVAh and sometimes includes kVAh which is not necessary to calculate power factor correction requirements. When you open the CSV file, you will be presented with columns as shown below.

	A	B	C	D	E	F
1	ICP	Date	Time	KWH	kVAh	kvarh
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248
3	0000007340UNB20	01.05.2014	00:30	3.872	4.481	2.256
4	0000007340UNB20	01.05.2014	01:00	3.904	4.545	2.328
5	0000007340UNB20	01.05.2014	01:30	3.816	4.429	2.248
6	0000007340UNB20	01.05.2014	02:00	3.488	3.978	1.912
7	0000007340UNB20	01.05.2014	02:30	3.080	3.463	1.584

The formula used to calculate kVAr required to correct power factor to a specified target is shown below.

$$kVAr = kW(\tan Ø_1 - \tan Ø_2)$$

To carry out the calculation above, we need to derive kW from kWH and phase angle from power factor which is calculated by using kWH and KVArH. Power factor could also be calculated using kWH and kVAH but as kVAH not always available, kWH and KVArH will be used. Add the title "kVA" to a column and apply the formula as shown below. Please note that kWH is the amount of kilowatts used over one hour. As our data is in half hour intervals, kW = kWH*2. Likewise, kVAr = kVArH*2.



To calculate kVA, using theorem of Pythagoras, it can be seen that $kVA = \sqrt{(kW^2 + kVAR^2)}$
From our meter data, this becomes $kVA = \sqrt{((kWH*2)^2 + (kVArH*2)^2)}$

In our file above, in row 2, kWH = D2 and kVARH = E2.

Thus, the excel formula for kVA is =SQRT(((D2*2)^2)+((F2*2)^2)). This is shown below.

H2 =SQRT(((D2*2)^2)+((F2*2)^2))

	A	B	C	D	E	F	G	H
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532

Next we need to calculate power factor. Head column I “P/Factor “or similar and calculate power factor using kWH and kVARH. If kVAH is available, PF could be calculated using

PF = kWH/kVAH

But as kVAH is not always available from a utility meter kWH and kVARH will be used. From Pythagoras, kVAH = $\sqrt{}(kWH^2 + kVARH^2)$ so,

$$PF = kWH / \sqrt{}(kWH^2 + kVARH^2)$$

In excel format, this is expressed as =D2/(SQRT(D2^2+F2^2)) as shown below.

I2 =D2/(SQRT(D2^2+F2^2))

	A	B	C	D	E	F	G	H	I
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071

Now that we have kVA and power factor, we can calculate kW as kW=kVA*power factor. Head column J kW and calculate kW = H2*I2

J2 =H2*I2

	A	B	C	D	E	F	G	H	I	J
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor	kw
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071	7.776

As a check that our earlier assumption that kW = kWH*2 is correct, we now check relationship between recorded kWH and calculated kW. kW = 2*kWH so kW/kWH should equal 2. Head column K “check” and make cell2=J2/D2

K2 =J2/D2

	A	B	C	D	E	F	G	H	I	J	K
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor	kw	check
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071	7.776	2

As predicted, kW/kWH=2.

If we go back to our formula to calculate required kVAR, kVAr = kW($\tan Ø_1 - \tan Ø_2$)
We now need to determine values of $\tan Ø_1$ and $\tan Ø_2$. Head columns L $\tan Ø_1$ and column M $\tan Ø_2$

Tan $Ø_1$ is the tangent of the phase angle when the power factor is equal to our recorded value. Tan $Ø_1$ =Tan($\cos^{-1}$(power factor))

In excel format, to calculate this value in cell L2 = TAN(ACOS(I2))

L2 =TAN(ACOS(I2))

	A	B	C	D	E	F	G	H	I	J	K	L
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor	kw	check	tanphi_1
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071	7.776	2	0.5781893

The formula $\tan Ø_2$ is the same but instead of recorded power factor, we enter target power factor, in this case, 0.96.

M2 =TAN(ACOS(0.96))

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor	kw	check	tanphi_1	tanphi2
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071	7.776	2	0.5781893	0.29166667

The data is now exactly as it is needed. Next, we will use the data to calculate required kVARs. This applies the formula shown below and is =J2*(L2-M2)

$$kVAr = kW(\tan Ø_1 - \tan Ø_2)$$

N2 =J2*(L2-M2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	ICP	Date	Time	KWH	kVAh	kvarh		kVa	P/Factor	kw	check	tanphi_1	tanphi2	kVAr
2	0000007340UNB20	01.05.2014	00:00	3.888	4.491	2.248		8.98221532	0.86571071	7.776	2	0.5781893	0.29166667	2.228

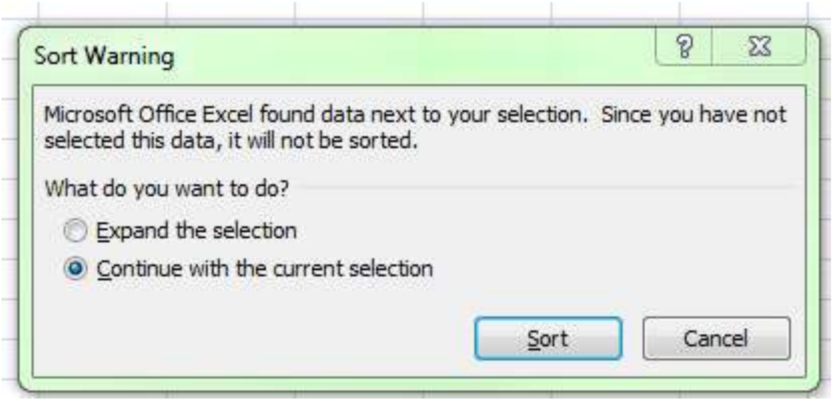
Next columns H →N need to be extended the full length of the spreadsheet. To do this, highlight cell H2. Click onto bottom right corner of cell and with left mouse button held down, drag the bottom right corner of the cell to the bottom of the spreadsheet. Do the same for I→ N.

We now have a column of values of kVAr required to correct average power factor to target power factor over half hour intervals. Now we need to find the highest value required.

Highlight Column N and "Paste Values" (click tab under paste button shown below to open a drop down menu and click "paste values") to columns O and P.

Highlight column P and click onto tab shown under "Sort and Filter as shown below. This will bring up a drop down menu. Select "Sort Largest to Smallest".

A warning will pop up (shown below). Select "continue with current selection" and click "sort".



This will bring the highest value of kVAr required to correct power factor to target value during the recording period into cell I2 (highlighted red below).

H	I	J	K	L	M	N	O	P
kVa	P/Factor	kw	check	tanphi_1	tanphi2	kVAr	kVAr	kVAr
8.98221532	0.86571071	7.776	2	0.5781893	0.29166667	2.228	2.228	#DIV/0!
8.96257106	0.86403778	7.744	2	0.58264463	0.29166667	2.25333333	2.25333333	#DIV/0!
9.09083055	0.85888742	7.808	2	0.59631148	0.29166667	2.37866667	2.37866667	#DIV/0!
8.85784624	0.861609	7.632	2	0.58909853	0.29166667	2.27	2.27	#DIV/0!
7.95534738	0.87689445	6.976	2	0.54816514	0.29166667	1.78933333	1.78933333	#DIV/0!
6.92689137	0.8892878	6.16	2	0.51428571	0.29166667	1.37133333	1.37133333	#DIV/0!
7.17101722	0.88578786	6.352	2	0.52392947	0.29166667	1.47533333	1.47533333	#DIV/0!
8.8272741	0.92984538	8.208	2	0.3957115	0.29166667	0.854	0.854	#DIV/0!
9.38579693	0.92906336	8.72	2	0.39816514	0.29166667	0.92866667	0.92866667	#DIV/0!
8.83901171	0.93766139	8.288	2	0.37065637	0.29166667	0.65466667	0.65466667	#DIV/0!
9.605665	0.92778584	8.912	2	0.4021544	0.29166667	0.98466667	0.98466667	#DIV/0!
8.78844332	0.93759494	8.24	2	0.37087379	0.29166667	0.65266667	0.65266667	#DIV/0!
9.22244219	0.92990553	8.576	2	0.39552239	0.29166667	0.89066667	0.89066667	#DIV/0!
12.3464132	0.9045542	11.168	2	0.4713467	0.29166667	2.00666667	2.00666667	#DIV/0!
61.8763774	0.79280659	49.056	2	0.76875408	0.29166667	23.404	23.404	#DIV/0!
83.708558	0.72957893	61.072	2	0.93738538	0.29166667	39.4353333	39.4353333	#DIV/0!
87.1680015	0.75330395	65.664	2	0.87305068	0.29166667	38.176	38.176	#DIV/0!
79.2813691	0.68777823	54.528	2	1.05545775	0.29166667	41.648	41.648	#DIV/0!
91.9334396	0.72556841	66.704	2	0.94842888	0.29166667	43.8086667	43.8086667	#DIV/0!
85.6893918	0.73456	62.944	2	0.92374174	0.29166667	39.7853333	39.7853333	#DIV/0!
49.2453541	0.80283716	39.536	2	0.74261433	0.29166667	17.8286667	17.8286667	#DIV/0!
47.4713556	0.8092459	38.416	2	0.72594752	0.29166667	16.6833333	16.6833333	#DIV/0!
70.7357991	0.83850046	59.312	2	0.64985163	0.29166667	21.2446667	21.2446667	#DIV/0!
53.2000602	0.75999914	40.432	2	0.85516423	0.29166667	22.7833333	22.7833333	#DIV/0!
103.18968	0.78023306	80.512	2	0.80166932	0.29166667	41.0613333	41.0613333	#DIV/0!
118.792263	0.77957939	92.608	2	0.80338632	0.29166667	47.3893333	47.3893333	82.954
90.2616286	0.88755323	80.112	2	0.5190733	0.29166667	18.218	18.218	76.6373333

Ignore the #DIV/0! Error and select the highest value, in this case, 82.95kVAr.
This error arose when power consumption was zero as shown below.

1440	0000007340UNB20	01.08.2014	11:00	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1441	0000007340UNB20	01.08.2014	11:30	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1442	0000007340UNB20	01.08.2014	12:00	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1443	0000007340UNB20	01.08.2014	12:30	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1444	0000007340UNB20	01.08.2014	13:00	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1445	0000007340UNB20	01.08.2014	13:30	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1446	0000007340UNB20	01.08.2014	14:00	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1447	0000007340UNB20	01.08.2014	14:30	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!
1448	0000007340UNB20	01.08.2014	15:00	0.000	0.000	0.000		0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.29166667	#DIV/0!	#DIV/0!

In column I, when calculating power factor, the denominator of our fractional sum was zero. In this example, 100kVAr of power factor correction would be recommended.