

## Suplimentary Material

J.A. Moreno, R. Muñoz, A Simple Method to Estimate the Degraded Photovoltaic Modules from the String Open-Circuit Voltage in Solar Pumping Systems

### Features of the plants

| Installation | Town    | Modules/String | Strings | Modules | Power (W) |
|--------------|---------|----------------|---------|---------|-----------|
| Plant 1      | MONTORO | 16             | 41      | 656     | 114.800   |
| Plant 2      | CARDEÑA | 16             | 38      | 608     | 106.400   |
| Plant 3      | CARDEÑA | 16             | 38      | 608     | 106.400   |

### Features of the modules

|        | Peak power (pp) | Voc   | Isc  | Vpp  | Ipp  | TONC |
|--------|-----------------|-------|------|------|------|------|
|        | W               | V     | A    | V    | A    | °C   |
| Module | 175             | 42,6  | 5,52 | 35,5 | 4,93 | 48   |
| String | 2800            | 681,6 | 5,52 | 568  | 4,93 |      |

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## Temporal series of monthly produced energy (kWh)

| Plant 1 |         |         |         |         |         |         |        |        |        |        |         |         |
|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|---------|---------|
| Month   | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016   | 2017   | 2018   | 2019   | 2020    | 2021    |
| Jan     | 6.975   | 8.475   | 12.108  | 8.327   | 7.205   | 9.832   | 6.097  | 7.270  | 4.411  | 5.466  | 8.566   | 7.203   |
| Feb     | 8.004   | 12.352  | 16.280  | 11.638  | 7.206   | 10.072  | 7.346  | 5.103  | 5.003  | 5.350  | 11.207  | 8.453   |
| Mar     | 12.879  | 13.698  | 16.873  | 9.845   | 13.860  | 11.898  | 10.014 | 6.556  | 4.474  | 5.994  | 11.304  | 12.647  |
| Apr     | 15.826  | 14.713  | 14.534  | 14.341  | 12.650  | 9.239   | 8.199  | 5.319  | 4.516  | 4.951  | 11.465  | 10.472  |
| May     | 17.948  | 16.029  | 16.125  | 16.116  | 14.703  | 10.649  | 7.445  | 3.961  | 3.496  | 4.204  | 11.497  | 11.227  |
| Jun     | 16.186  | 17.001  | 16.467  | 15.054  | 13.368  | 9.497   | 6.234  | 2.879  | 4.089  | 3.790  | 12.286  | 10.384  |
| Jul     | 17.121  | 17.162  | 16.994  | 15.421  | 13.314  | 8.306   | 5.102  | 2.679  | 4.884  | 3.333  | 9.751   | 10.365  |
| Aug     | 16.438  | 16.537  | 15.583  | 14.811  | 12.243  | 7.992   | 4.818  | 2.495  | 4.087  | 2.681  | 11.064  | 9.516   |
| Sep     | 15.730  | 15.729  | 13.017  | 12.728  | 10.006  | 8.052   | 5.359  | 3.024  | 4.007  | 3.516  | 9.928   | 12.177  |
| Oct     | 13.643  | 14.469  | 12.235  | 12.502  | 10.235  | 6.720   | 4.742  | 2.949  | 4.396  | 3.673  | 10.728  | 9.010   |
| Nov     | 9.038   | 9.019   | 8.572   | 11.357  | 7.365   | 7.690   | 5.760  | 4.643  | 3.997  | 4.320  | 7.572   | 8.606   |
| Dec     | 7.141   | 10.256  | 8.541   | 9.772   | 8.539   | 7.151   | 5.753  | 4.670  | 5.195  | 4.933  | 6.906   | 7.106   |
| Annual  | 156.929 | 165.440 | 167.329 | 151.912 | 130.694 | 107.098 | 76.869 | 51.548 | 52.555 | 52.210 | 122.274 | 117.166 |

| Plant 3 |         |         |         |         |         |         |         |         |         |         |         |         |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Month   | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    |
| Jan     | 9.504   | 7.101   | 9.309   | 6.601   | 6.003   | 9.080   | 5.994   | 8.851   | 7.187   | 7.826   | 6.128   | 10.294  |
| Feb     | 5.820   | 11.627  | 15.093  | 11.349  | 7.073   | 10.592  | 8.763   | 7.839   | 10.490  | 11.531  | 10.060  | 9.296   |
| Mar     | 11.801  | 12.781  | 16.379  | 9.496   | 14.394  | 15.135  | 15.025  | 13.346  | 10.124  | 13.942  | 10.823  | 11.531  |
| Apr     | 15.767  | 13.947  | 13.541  | 13.977  | 14.550  | 14.147  | 13.154  | 15.986  | 12.693  | 10.982  | 10.033  | 8.733   |
| May     | 17.438  | 16.119  | 16.582  | 15.853  | 17.680  | 17.206  | 14.670  | 15.710  | 13.379  | 14.255  | 11.948  | 10.992  |
| Jun     | 15.984  | 17.249  | 17.020  | 16.343  | 16.867  | 16.313  | 16.997  | 15.739  | 9.052   | 14.549  | 12.627  | 9.776   |
| Jul     | 16.166  | 17.907  | 17.964  | 17.845  | 17.589  | 17.243  | 16.326  | 16.146  | 6.835   | 13.806  | 12.632  | 9.627   |
| Aug     | 16.013  | 16.878  | 16.276  | 17.004  | 17.120  | 15.422  | 16.289  | 14.612  | 13.588  | 12.696  | 12.272  | 8.388   |
| Sep     | 14.959  | 15.684  | 13.273  | 13.695  | 12.933  | 14.057  | 15.028  | 14.566  | 11.625  | 11.034  | 11.876  | 8.149   |
| Oct     | 12.446  | 13.559  | 12.124  | 12.621  | 12.763  | 9.894   | 11.837  | 12.853  | 9.837   | 10.664  | 12.024  | 7.451   |
| Nov     | 8.011   | 7.930   | 7.225   | 9.678   | 7.399   | 10.383  | 8.236   | 11.114  | 5.895   | 5.253   | 9.960   | 6.465   |
| Dec     | 5.141   | 6.655   | 5.928   | 6.759   | 6.779   | 6.636   | 6.591   | 6.062   | 6.603   | 4.916   | 10.294  | 4.342   |
| Annual  | 149.050 | 157.437 | 160.714 | 151.221 | 151.150 | 156.108 | 148.910 | 152.824 | 117.308 | 131.454 | 130.677 | 105.044 |

| Plant 2 |         |         |         |         |         |         |         |         |        |        |        |         |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|---------|
| Month   | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018   | 2019   | 2020   | 2021    |
| Jan     | 7.946   | 7.007   | 9.190   | 6.527   | 5.929   | 8.886   | 6.182   | 8.565   | 6.600  | 668    | 4.855  | 5.511   |
| Feb     | 6.841   | 11.532  | 15.117  | 11.362  | 7.061   | 10.437  | 9.041   | 7.644   | 9.602  | 7.668  | 6.743  | 7.561   |
| Mar     | 11.759  | 12.624  | 16.445  | 9.486   | 14.410  | 15.032  | 13.862  | 12.691  | 9.222  | 8.758  | 7.989  | 12.032  |
| Apr     | 15.719  | 13.888  | 13.480  | 13.992  | 14.719  | 13.994  | 14.410  | 14.826  | 10.960 | 7.885  | 6.800  | 8.889   |
| May     | 17.344  | 15.884  | 16.567  | 15.831  | 17.599  | 17.116  | 15.602  | 14.087  | 10.910 | 8.792  | 6.863  | 12.416  |
| Jun     | 15.804  | 17.043  | 16.910  | 16.299  | 16.515  | 14.094  | 13.747  | 13.400  | 9.483  | 9.437  | 6.181  | 12.685  |
| Jul     | 17.407  | 17.696  | 17.819  | 17.511  | 16.485  | 14.146  | 13.609  | 13.071  | 9.752  | 8.457  | 3.950  | 12.554  |
| Aug     | 15.952  | 16.809  | 16.083  | 16.379  | 15.847  | 12.499  | 12.133  | 11.767  | 8.330  | 7.354  | 12.049 | 11.042  |
| Sep     | 14.800  | 15.703  | 13.226  | 13.158  | 12.175  | 12.007  | 11.839  | 11.670  | 7.393  | 7.062  | 9.836  | 7.447   |
| Oct     | 13.573  | 13.573  | 12.044  | 12.664  | 12.667  | 9.379   | 9.957   | 10.535  | 7.106  | 6.805  | 10.226 | 9.535   |
| Nov     | 7.903   | 7.834   | 7.166   | 9.587   | 7.252   | 6.903   | 7.734   | 8.564   | 4.894  | 4.512  | 6.178  | 7.650   |
| Dec     | 4.994   | 6.450   | 5.759   | 6.525   | 6.562   | 6.174   | 6.303   | 5.382   | 2.701  | 3.773  | 4.659  | 4.764   |
| Annual  | 150.042 | 156.043 | 159.806 | 149.321 | 147.221 | 140.667 | 134.416 | 132.202 | 96.953 | 81.171 | 86.329 | 112.086 |

|         | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Plant 1 | 156.929 | 165.440 | 167.329 | 151.912 | 130.694 | 107.098 | 76.869  | 51.548  | 52.555  | 52.210  | 122.274 | 117.166 |
| Plant 3 | 149.050 | 157.437 | 160.714 | 151.221 | 151.150 | 156.108 | 148.910 | 152.824 | 117.308 | 131.454 | 130.677 | 105.044 |
| Plant 2 | 150.042 | 156.043 | 159.806 | 149.321 | 147.221 | 140.667 | 134.416 | 132.202 | 96.953  | 81.171  | 86.329  | 112.086 |

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## Monthly annual comparative of energy production by plant (kWh)

| January   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Plant 1   | 6.975  | 8.475  | 12.108 | 8.327  | 7.205  | 9.832  | 6.097  | 7.270  | 4.411  | 5.466  | 8.566  | 7.203  |
| Plant 3   | 9.504  | 7.101  | 9.309  | 6.601  | 6.003  | 9.080  | 5.994  | 8.851  | 7.187  | 7.826  | 6.128  | 10.294 |
| Plant 2   | 7.946  | 7.007  | 9.190  | 6.527  | 5.929  | 8.886  | 6.182  | 8.565  | 6.600  | 668    | 4.855  | 5.511  |
| February  | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 8.004  | 12.352 | 16.280 | 11.638 | 7.206  | 10.072 | 7.346  | 5.103  | 5.003  | 5.350  | 11.207 | 8.453  |
| Plant 3   | 5.820  | 11.627 | 15.093 | 11.349 | 7.073  | 10.592 | 8.763  | 7.839  | 10.490 | 11.531 | 10.060 | 9.296  |
| Plant 2   | 6.841  | 11.532 | 15.117 | 11.362 | 7.061  | 10.437 | 9.041  | 7.644  | 9.602  | 7.668  | 6.743  | 7.561  |
| March     | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 12.879 | 13.698 | 16.873 | 9.845  | 13.860 | 11.898 | 10.014 | 6.556  | 4.474  | 5.994  | 11.304 | 12.647 |
| Plant 3   | 11.801 | 12.781 | 16.379 | 9.496  | 14.394 | 15.135 | 15.025 | 13.346 | 10.124 | 13.942 | 10.823 | 11.531 |
| Plant 2   | 11.759 | 12.624 | 16.445 | 9.486  | 14.410 | 15.032 | 13.862 | 12.691 | 9.222  | 8.758  | 7.989  | 12.032 |
| April     | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 15.826 | 14.713 | 14.534 | 14.341 | 12.650 | 9.239  | 8.199  | 5.319  | 4.516  | 4.951  | 11.465 | 10.472 |
| Plant 3   | 15.767 | 13.947 | 13.541 | 13.977 | 14.550 | 14.147 | 13.154 | 15.986 | 12.693 | 10.982 | 10.033 | 8.733  |
| Plant 2   | 15.719 | 13.888 | 13.480 | 13.992 | 14.719 | 13.994 | 14.410 | 14.826 | 10.960 | 7.885  | 6.800  | 8.889  |
| May       | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 17.948 | 16.029 | 16.125 | 16.116 | 14.703 | 10.649 | 7.445  | 3.961  | 3.496  | 4.204  | 11.497 | 11.227 |
| Plant 3   | 17.438 | 16.119 | 16.582 | 15.853 | 17.680 | 17.206 | 14.670 | 15.710 | 13.379 | 14.255 | 11.948 | 10.992 |
| Plant 2   | 17.344 | 15.884 | 16.567 | 15.831 | 17.599 | 17.116 | 15.602 | 14.087 | 10.910 | 8.792  | 6.863  | 12.416 |
| June      | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 16.186 | 17.001 | 16.467 | 15.054 | 13.368 | 9.497  | 6.234  | 2.879  | 4.089  | 3.790  | 12.286 | 10.384 |
| Plant 3   | 15.984 | 17.249 | 17.020 | 16.343 | 16.867 | 16.313 | 16.997 | 15.739 | 9.052  | 14.549 | 12.627 | 9.776  |
| Plant 2   | 15.804 | 17.043 | 16.910 | 16.299 | 16.515 | 14.094 | 13.747 | 13.400 | 9.483  | 9.437  | 6.181  | 12.685 |
| July      | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 17.121 | 17.162 | 16.994 | 15.421 | 13.314 | 8.306  | 5.102  | 2.679  | 4.884  | 3.333  | 9.751  | 10.365 |
| Plant 3   | 16.166 | 17.907 | 17.964 | 17.845 | 17.589 | 17.243 | 16.326 | 16.146 | 6.835  | 13.806 | 12.632 | 9.627  |
| Plant 2   | 17.407 | 17.696 | 17.819 | 17.511 | 16.485 | 14.146 | 13.609 | 13.071 | 9.752  | 8.457  | 3.950  | 12.554 |
| August    | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 16.438 | 16.537 | 15.583 | 14.811 | 12.243 | 7.992  | 4.818  | 2.495  | 4.087  | 2.681  | 11.064 | 9.516  |
| Plant 3   | 16.013 | 16.878 | 16.276 | 17.004 | 17.120 | 15.422 | 16.289 | 14.612 | 13.588 | 12.696 | 12.272 | 8.388  |
| Plant 2   | 15.952 | 16.809 | 16.083 | 16.379 | 15.847 | 12.499 | 12.133 | 11.767 | 8.330  | 7.354  | 12.049 | 11.042 |
| September | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 15.730 | 15.729 | 13.017 | 12.728 | 10.006 | 8.052  | 5.359  | 3.024  | 4.007  | 3.516  | 9.928  | 12.177 |
| Plant 3   | 14.959 | 15.684 | 13.273 | 13.695 | 12.933 | 14.057 | 15.028 | 14.566 | 11.625 | 11.034 | 11.876 | 8.149  |
| Plant 2   | 14.800 | 15.703 | 13.226 | 13.158 | 12.175 | 12.007 | 11.839 | 11.670 | 7.393  | 7.062  | 9.836  | 7.447  |
| October   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 13.643 | 14.469 | 12.235 | 12.502 | 10.235 | 6.720  | 4.742  | 2.949  | 4.396  | 3.673  | 10.728 | 9.010  |
| Plant 3   | 12.446 | 13.559 | 12.124 | 12.621 | 12.763 | 9.894  | 11.837 | 12.853 | 9.837  | 10.664 | 12.024 | 7.451  |
| Plant 2   | 13.573 | 13.573 | 12.044 | 12.664 | 12.667 | 9.379  | 9.957  | 10.535 | 7.106  | 6.805  | 10.226 | 9.535  |
| November  | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 9.038  | 9.019  | 8.572  | 11.357 | 7.365  | 7.690  | 5.760  | 4.643  | 3.997  | 4.320  | 7.572  | 8.606  |
| Plant 3   | 8.011  | 7.930  | 7.225  | 9.678  | 7.399  | 10.383 | 8.236  | 11.114 | 5.895  | 5.253  | 9.960  | 6.465  |
| Plant 2   | 7.903  | 7.834  | 7.166  | 9.587  | 7.252  | 6.903  | 7.734  | 8.564  | 4.894  | 4.512  | 6.178  | 7.650  |
| December  | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   |
| Plant 1   | 7.141  | 10.256 | 8.541  | 9.772  | 8.539  | 7.151  | 5.753  | 4.670  | 5.195  | 4.933  | 6.906  | 7.106  |
| Plant 3   | 5.141  | 6.655  | 5.928  | 6.759  | 6.779  | 6.636  | 6.591  | 6.062  | 6.603  | 4.916  | 10.294 | 4.342  |
| Plant 2   | 4.994  | 6.450  | 5.759  | 6.525  | 6.562  | 6.174  | 6.303  | 5.382  | 2.701  | 3.773  | 4.659  | 4.764  |

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### Mean temperatures

Town/year

|         | Jan | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
|---------|-----|------|------|------|------|------|------|------|------|------|------|------|
| CARDEÑA |     |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 7,4 | 9,6  | 11,8 | 16,2 | 19,1 | 25,7 | 26,8 | 26,6 | 22,6 | 20,9 | 12,9 | 8    |
| 2018    | 7,9 | 7,2  | 8,3  | 13   | 15,9 | 20,9 | 24,1 | 27,6 | 23,8 | 16,2 | 10,3 |      |
| 2019    |     |      |      | 12   | 19,4 | 22   | 25,6 | 26,4 | 22,3 | 18,2 | 9,5  |      |
| MONTORO |     |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 7,9 | 12,2 | 14,1 | 18,1 | 21,9 | 28,5 | 28,9 | 28,9 | 24,4 | 21,3 | 12,7 | 8,8  |
| 2018    | 9,1 | 8,6  | 12   | 16,2 | 19,2 | 24,9 | 27,5 | 29,7 | 26,1 | 18,4 | 13   | 10,5 |
| 2019    | 7,9 | 10,8 | 13,7 | 15,1 | 21,9 | 24,3 | 28,3 | 28,3 | 24,3 | 19,5 | 12,4 |      |

### Mean of maximum temperatures

|         | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|
| CARDEÑA |      |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 12,5 | 13,5 | 17,5 | 22,7 | 25,7 | 33,7 | 34,8 | 34,2 | 30   | 27,3 | 18,3 | 12,3 |
| 2018    | 12,1 | 12,2 | 12   | 18,1 | 21,8 | 27,7 | 32,1 | 35,3 | 30,6 | 21,3 | 13,8 |      |
| 2019    |      |      |      | 26,6 | 32,5 | 38,5 | 38,7 | 37,1 | 35,5 | 31,7 | 23,3 |      |
| MONTORO |      |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 15,5 | 17,5 | 21,3 | 26,8 | 30,5 | 38   | 39   | 38,6 | 34,1 | 31   | 21,3 | 15,5 |
| 2018    | 15,1 | 16   | 16,6 | 22,5 | 26,9 | 33,7 | 37,6 | 40,1 | 34,6 | 25,5 | 18   | 18,1 |
| 2019    | 16   | 20   | 22,6 | 21,5 | 30,8 | 33,2 | 36,9 | 37,9 | 32,1 | 27,6 | 17,1 |      |

### Absolute maximum temperatures

|         | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|
| CARDEÑA |      |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 17,9 | 19,5 | 26,9 | 29,4 | 33,1 | 39,2 | 42,5 | 39,6 | 34,9 | 31,7 | 22,8 | 17   |
| 2018    | 21   | 18,6 | 21,3 | 26,6 | 27,3 | 37,4 | 35,9 | 40,3 | 36,8 | 29,7 | 19,5 |      |
| 2019    |      |      |      | 26,6 | 32,5 | 38,5 | 38,7 | 37,1 | 35,5 | 31,7 | 23,3 |      |
| MONTORO |      |      |      |      |      |      |      |      |      |      |      |      |
| 2017    | 21,5 | 23,3 | 30,1 | 33,6 | 38,4 | 43,9 | 47,3 | 44,4 | 38,8 | 35,8 | 26,7 | 20,6 |
| 2018    | 22,3 | 22,4 | 24,9 | 30   | 31,1 | 42,1 | 41,6 | 45,6 | 41,2 | 33,8 | 23   | 24   |
| 2019    | 21   | 24,6 | 27,2 | 30,9 | 36,3 | 41,3 | 42,3 | 41,3 | 39,1 | 34,4 | 26,7 |      |

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### Plant 1: string open circuit voltage measurements

| String | Wrong  | Right | Total  | jul-18 | Name Volt |
|--------|--------|-------|--------|--------|-----------|
| String | ≤ 26 V | ~40 V |        |        |           |
| 1      | 9      | 7     | 16     | 488    | 681,6     |
| 2      | 6      | 10    | 16     | 465    | 681,6     |
| 3      | 9      | 7     | 16     | 471    | 681,6     |
| 4      | 7      | 9     | 16     | 454    | 681,6     |
| 5      | 13     | 3     | 16     | 390    | 681,6     |
| 6      | 0      | 16    | 16     | 628    | 681,6     |
| 7      | 0      | 16    | 16     | 627    | 681,6     |
| 8      | 7      | 9     | 16     | 464    | 681,6     |
| 9      | 6      | 10    | 16     | 472    | 681,6     |
| 10     | 14     | 2     | 16     | 400    | 681,6     |
| 11     | 8      | 8     | 16     | 491    | 681,6     |
| 12     | 7      | 9     | 16     | 477    | 681,6     |
| 13     | 3      | 13    | 16     | 414    | 681,6     |
| 14     | 10     | 6     | 16     | 427    | 681,6     |
| 15     | 8      | 8     | 16     | 418    | 681,6     |
| 16     | 3      | 13    | 16     | 465    | 681,6     |
| 17     | 10     | 6     | 16     | 487    | 681,6     |
| 18     | 0      | 16    | 16     | 630    | 681,6     |
| 19     | 2      | 14    | 16     | 595    | 681,6     |
| 20     | 4      | 12    | 16     | 530    | 681,6     |
| 21     | 9      | 7     | 16     | 451    | 681,6     |
| 22     | 6      | 10    | 16     | 487    | 681,6     |
| 23     | 3      | 13    | 16     | 560    | 681,6     |
| 24     | 7      | 9     | 16     | 530    | 681,6     |
| 25     | 5      | 11    | 16     | 488    | 681,6     |
| 26     | 7      | 9     | 16     | 460    | 681,6     |
| 27     | 11     | 5     | 16     | 439    | 681,6     |
| 28     | 5      | 11    | 16     | 440    | 681,6     |
| 29     | 0      | 16    | 16     | 642    | 681,6     |
| 30     | 10     | 6     | 16     | 432    | 681,6     |
| 31     | 10     | 6     | 16     | 444    | 681,6     |
| 32     | 6      | 10    | 16     | 420    | 681,6     |
| 33     | 6      | 10    | 16     | 527    | 681,6     |
| 34     | 8      | 8     | 16     | 469    | 681,6     |
| 35     | 7      | 9     | 16     | 493    | 681,6     |
| 36     | 8      | 8     | 16     | 450    | 681,6     |
| 37     | 5      | 11    | 16     | 440    | 681,6     |
| 38     | 4      | 12    | 16     | 520    | 681,6     |
| 39     | 3      | 13    | 16     | 530    | 681,6     |
| 40     | 2      | 14    | 16     | 585    | 681,6     |
| 41     | 0      | 16    | 16     | 614    | 681,6     |
| Sum    | 248    | 408   | 656    |        |           |
|        | 37,8%  | 62,2% | 100,0% |        |           |

## Suplimentary Material

J.A. Moreno, R. Muñoz, A Simple Method to Estimate the Degraded Photovoltaic Modules from the String  
Open-Circuit Voltage in Solar Pumping Systems

### Plant 2: string open circuit voltage measurements

V-2020

| String        | Wrong  |        | Right  | Total  | 2.30 | 11 JU | Name Volt |
|---------------|--------|--------|--------|--------|------|-------|-----------|
|               | ~26 V  | ~12 V  | ~40 V  |        |      |       |           |
| 1             | 0      | 0      | 16     | 16     | 660  | 681,6 |           |
| 2             | 1      | 0      | 15     | 16     | 641  | 681,6 |           |
| 3             | 1      | 2      | 13     | 16     | 585  | 681,6 |           |
| 4             | 0      | 2      | 14     | 16     | 582  | 681,6 |           |
| 5             | 3      | 1      | 12     | 16     | 581  | 681,6 |           |
| 6             | 4      | 0      | 12     | 16     | 569  | 681,6 |           |
| 7             | 0      | 1      | 15     | 16     | 595  | 681,6 |           |
| 8             | 0      | 0      | 16     | 16     | 647  | 681,6 |           |
| 9             | 1      | 4      | 11     | 16     | 511  | 681,6 |           |
| 10            | 2      | 0      | 14     | 16     | 614  | 681,6 |           |
| 11            | 4      | 2      | 10     | 16     | 521  | 681,6 |           |
| 12            | 5      | 3      | 8      | 16     | 467  | 681,6 |           |
| 13            | 4      | 4      | 8      | 16     | 519  | 681,6 |           |
| 14            | 2      | 2      | 12     | 16     | 571  | 681,6 |           |
| 15            | 3      | 3      | 10     | 16     | 538  | 681,6 |           |
| 16            | 4      | 3      | 9      | 16     | 562  | 681,6 |           |
| 17            |        |        |        |        | 559  | 681,6 |           |
| 18            |        |        |        |        | 571  | 681,6 |           |
| 19            |        |        |        |        | 547  | 681,6 |           |
| 20            |        |        |        |        | 595  | 681,6 |           |
| 21            |        |        |        |        | 571  | 681,6 |           |
| 22            | 1      | 1      | 14     | 16     | 580  | 681,6 |           |
| 23            | 3      | 3      | 10     | 16     | 510  | 681,6 |           |
| 24            | 1      | 3      | 12     | 16     | 518  | 681,6 |           |
| 25            | 5      | 5      | 6      | 16     | 446  | 681,6 |           |
| 26            | 4      | 1      | 11     | 16     | 552  | 681,6 |           |
| 27            | 3      | 0      | 13     | 16     | 617  | 681,6 |           |
| 28            | 7      | 1      | 8      | 16     | 509  | 681,6 |           |
| 29            | 3      | 2      | 11     | 16     | 546  | 681,6 |           |
| 30            | 4      | 2      | 10     | 16     | 542  | 681,6 |           |
| 31            | 4      | 3      | 9      | 16     | 510  | 681,6 |           |
| 32            | 2      | 2      | 12     | 16     | 602  | 681,6 |           |
| 33            | 7      | 3      | 6      | 16     | 455  | 681,6 |           |
| 34            | 6      | 1      | 9      | 16     | 529  | 681,6 |           |
| 35            | 4      | 0      | 12     | 16     | 592  | 681,6 |           |
| 36            | 4      | 7      | 5      | 16     | 434  | 681,6 |           |
| 37            | 2      | 0      | 14     | 16     | 617  | 681,6 |           |
| 38            | 1      | 0      | 15     | 16     | 634  | 681,6 |           |
| Sum           | 95     | 61     | 372    | 528    |      |       |           |
| Gouping wrong |        | 156    | 372    | 528    |      |       |           |
|               | 17,99% | 11,55% | 70,45% | 100,0% |      |       |           |
| Wrong         |        | 29,55% |        |        |      |       |           |