

## 9 References

- [1] A. Aris and B. Shabani, "Sustainable Power Supply Solutions for Off-Grid Base Stations," *Energies*, vol. 8, no. 10, pp. 10904–10941, Sep. 2015.
- [2] S. Lambert, W. Van Heddeghem, W. Vereecken, B. Lannoo, D. Colle, and M. Pickavet, "Worldwide electricity consumption of communication networks," *Opt. Express*, vol. 20, no. 26, pp. B513–B524, 2012.
- [3] A. Fehske, G. Fettweis, J. Malmodin, and G. Biczok, "The global footprint of mobile communications: The ecological and economic perspective," *IEEE Commun. Mag.*, vol. 49, no. 8, 2011.
- [4] C. R. Murthy and C. Kavitha, "A survey of green base stations in cellular networks," *Int. J. Comput. Netw. Wirel. Commun. IJCNWC*, vol. 2, no. 2, pp. 232–236, 2012.
- [5] "Etisalat web."
- [6] "Ecoscore.html."
- [7] J. Lorincz, T. Garma, and G. Petrovic, "Measurements and Modelling of Base Station Power Consumption under Real Traffic Loads," *Sensors*, vol. 12, no. 12, pp. 4281–4310, Mar. 2012.
- [8] L. Decreusefond, T.-T. Vu, and P. Martins, "Modeling energy consumption in cellular networks," in *Teletraffic Congress (ITC), 2013 25th International*, 2013, pp. 1–7.
- [9] N. Faruk, A. A. Ayeni, M. Y. Muhammad, A. Abdulkarim, and O. Moses, "Hybrid power systems for cell sites in mobile cellular networks," *Cyber J. Multidiscip. J. Sci. Technol. J. Sel. Areas Renew. Sustain. Energy JRSE January Ed.*, 2012.
- [10] J. Lorincz and I. Bule, "Renewable energy sources for power supply of base station sites," *Int. J. Bus. Data Commun. IJBDCN*, vol. 9, no. 3, pp. 53–74, 2013.
- [11] "Smart2020Report.pdf."
- [12] K. Kusakana and H. J. Vermaak, "Hybrid renewable power systems for mobile telephony base stations in developing countries," *Renew. Energy*, vol. 51, pp. 419–425, Mar. 2013.
- [13] International finance coperation, a world bank group, "Green power for mobile bi annual report 2014."
- [14] S. Paudel, J. N. Shrestha, F. J. Neto, J. A. Ferreira, and M. Adhikari, "Optimization of hybrid PV/wind power system for remote telecom station," in *Power and Energy Systems (ICPS), 2011 International Conference on*, 2011, pp. 1–6.
- [15] D. Bezmalinović, F. Barbir, and I. Tolj, "Techno-economic analysis of PEM fuel cells role in photovoltaic-based systems for the remote base stations," *Int. J. Hydrol. Energy*, vol. 38, no. 1, pp. 417–425, 2013.
- [16] E. F. F. Ribeiro, A. J. Marques Cardoso, and C. Boccaletti, "Uninterruptible energy production in standalone power systems for telecommunications," *Renew. Energy Power Qual. J.*, vol. 1, no. 07, pp. 351–356, Apr. 2009.
- [17] S. Goel and S. M. Ali, "Hybrid energy systems for off-grid remote telecom tower in Odisha, India," *Int. J. Ambient Energy*, vol. 36, no. 3, pp. 116–122, May 2015.
- [18] K. Ranjith Kumara, , P. Sruthib, and and M. Surya Kalavathi, "Power Management in Standalone Hybrid Power System." 29-Nov-2017.

- [19] P. Lehman, C. Chamberlin, J. Zoellick, R. Engel, and D. Rommel, “Fuel cell/photovoltaic integrated power system for a remote telecommunications repeater,” in *Proceedings of the 14th World Hydrogen Energy Conference, Montreal, QC, Canada*, 2002, pp. 9–14.
- [20] G. Koutitas and P. Demestichas, “A review of energy efficiency in telecommunication networks,” *Telfor J.*, vol. 2, no. 1, pp. 2–7, 2010.
- [21] <http://massiveelectronicsbd.com/client.php>, “Voltage dependent timers for generator controllers.” .
- [22] P. S. Georgilakis, “State-of-the-art of decision support systems for the choice of renewable energy sources for energy supply in isolated regions,” *Int. J. Distrib. Energy Resour.*, vol. 2, no. 2, pp. 129–150, 2005.
- [23] “Abu Taha and Daim - 2013 - Multi-Criteria Applications in Renewable Energy An.pdf.” .
- [24] iot.ieee.org, “Towards a definition of the Internet of Things (IoT).” .
- [25] <http://www.polytechnichub.com/advantages-disadvantages-microcontroller/>, “Advantages and disadvantages of microcontroller - Polytechnic Hub.html.” .
- [26] J. J. Grimm, “Electromagnetic linear actuator-design, manufacture and control,” 2009.
- [27] B. Yarborough, “Components and Methods for Current Measurement,” *Power Electron.*, 2012.
- [28] Texas instruments, “Universal Asynchronous Receiver/Transmitter (UART).” .



## 10 Annexure A

### Sample code listing - Ajax

```
<?php
include("dbconnection.php");
if(isset($_REQUEST["fromT"]) && isset($_REQUEST["untilT"])){
    $from = $_REQUEST["fromT"];
    $until = $_REQUEST["untilT"];
    $query1 = "SELECT msg_id from details where (mili_time>='$from' && mili_time<'$until')";
    mysqli_select_db($conn,"manjitha0717_db");
    $res = mysqli_query($conn,$query1);
    $ret = 0;
    $ids = array();
    if($res){
        while($row=mysqli_fetch_array($res,MYSQLI_ASSOC)){
            $id = $row['msg_id'];
            array_push($ids,$id);
        }
    }
    foreach ($ids as $id) {
        mysqli_select_db($conn,"genny");
        $query2 = "select * from details where msg_id='$id'";
        $res = mysqli_query($conn,$query2);
        $row=mysqli_fetch_array($res,MYSQLI_ASSOC);
        if($row['state'] == 'on'){
            $ret++;
        }
    }
    echo $ret*5 ;
    exit();
}
```

```

if(isset($_REQUEST["fromDTime"]) && isset($_REQUEST["untilTime"])){//give two milisecond vlues
to $from and $until

    $from = $_REQUEST["fromDTime"];
    $until = $_REQUEST["untilTime"];
    $query1 = "SELECT msg_id from details where (mili_time>='$from' && mili_time<'$until')";
    mysqli_select_db($conn,"manjitha0717_db");
    $res = mysqli_query($conn,$query1);
    $ret = 0;
    $ids = array();
    if($res){

        while($row=mysqli_fetch_array($res,MYSQLI_ASSOC)){
            $id = $row['msg_id'];
            array_push($ids,$id);
        }
    }

    foreach ($ids as $id) {
        mysqli_select_db($conn,"manjitha0717_db");
        $query2 = "select * from details where msg_id=\"$id\"";
        $res = mysqli_query($conn,$query2);
        $row=mysqli_fetch_array($res,MYSQLI_ASSOC);
        if($row['state'] == 'on'){
            $ret++;
        }
    }

    echo $ret*5;
    exit();
}

if(isset($_REQUEST["fromMTime"]) && isset($_REQUEST["untilTime"])){//give two milisecond
vlues to $from and $until

    $from = $_REQUEST["fromMTime"];

```

```

$until = $_REQUEST["untilTime"];

$query1 = "SELECT msg_id from details where (mili_time>='$from' && mili_time<'$until')";
mysqli_select_db($conn,"manjitha0717_db");
$res = mysqli_query
($conn,$query1);

$ret = 0;
$ids = array();
if($res){

    while($row=mysqli_fetch_array($res,MYSQLI_ASSOC)){
        $id = $row['msg_id'];
        array_push($ids,$id);
    }
}

foreach ($ids as $id) {
    mysqli_select_db($conn,"manjitha0717_db");
    $query2 = "select * from details where msg_id=\"$id\"";
    $res = mysqli_query($conn,$query2);
    $row=mysqli_fetch_array($res,MYSQLI_ASSOC);
    if($row['state'] == 'on'){
        $ret++;
    }
}

echo $ret*5;
exit();
}

?>

```

## 11 Annexure B

### Sample records

Time duration Minutes between two records	System Voltage	System current	Gen running Status
5	47	37	On
5	48	35	On
5	49	19	On
5	49	12	On
5	49	12	On
5	50	12	On
5	50	12	On
5	50	11	On
5	50	12	On
5	51	11	On
5	51	12	On
5	51	11	On
5	51	11	On
5	51	11	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	8	On
5	51	9	On
5	52	8	On
5	52	8	On
5	52	9	On
5	52	8	On
5	52	8	On
5	52	7	On
5	52	7	On
5	53	6	On
5	53	6	On

5	53	6	On
5	52	6	On
5	52	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	54	6	Off
5	50	14	Off
5	50	14	Off
5	50	13	Off
5	50	14	Off
5	50	14	Off
5	50	13	Off
5	50	14	Off
5	50	13	Off
5	50	14	Off
5	49	14	Off
5	49	13	Off
5	49	13	Off
5	49	13	Off
5	49	14	Off
5	49	12	Off
5	49	14	Off
5	49	12	Off
5	48	13	Off
5	48	14	Off
5	47	39	On
5	50	37	On
5	50	35	On
5	50	21	On
5	50	18	On
5	50	12	On
5	50	12	On
5	50	12	On

5	50	12	On
5	50	11	On
5	50	11	On
5	50	11	On
5	50	10	On
5	51	10	On
5	51	10	On
5	51	11	On
5	51	10	On
5	51	10	On
5	51	9	On
5	51	9	On
5	51	9	On
5	52	9	On
5	52	9	On
5	52	9	On
5	52	9	On
5	52	9	On
5	52	9	On
5	53	7	On
5	53	7	On
5	53	7	On
5	53	8	On
5	53	7	On
5	53	7	On
5	53	7	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	53	6	On
5	54	6	Off
5	52	14	Off
5	51	14	Off
5	51	13	Off
5	51	13	Off
5	50	13	Off
5	50	14	Off

5	50	13	Off
5	50	13	Off
5	50	13	Off
5	50	13	Off
5	49	14	Off
5	49	13	Off
5	48	14	Off
5	48	14	Off
5	47	35	On
5	51	35	On
5	49	27	On
5	49	18	On
5	49	17	On
5	49	17	On
5	49	12	On
5	49	11	On
5	50	10	On
5	50	11	On
5	50	9	On
5	50	9	On
5	50	9	On
5	50	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	9	On
5	51	7	On
5	51	7	On
5	51	7	On
5	51	7	On
5	51	6	On
5	53	6	On
5	53	6	On

5	53	6	On
5	53	9	On
5	53	7	On
5	53	7	On
5	53	6	On
5	53	6	On
5	52	6	On
5	54	6	On
5	54	6	On
5	54	6	On
5	54	6	On
5	54	6	On
5	54	6	On
5	54	6	On
5	54	6	Off
5	52	14	Off
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5	51	14	Off
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5	51	13	Off
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5	50	14	Off
5	50	13	Off
5	50	13	Off
5	49	13	Off
5	49	13	Off
5	49	14	Off
5	49	13	Off
5	50	13	On
5	49	13	On

5	48	38	On
5	49	33	On
5	49	23	On
5	49	19	On
5	49	12	On
5	49	11	On
5	49	11	On
5	49	11	On
5	49	12	On
5	49	12	On
5	50	11	On
5	50	11	On
5	50	11	On
5	50	10	On
5	50	10	On
5	49	9	On
5	50	9	On
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5	51	9	On
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5	51	9	On
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5	52	9	On
5	52	9	On
5	52	9	On
5	52	7	On
5	52	7	On
5	52	7	On
5	52	9	On
5	52	9	On
5	53	9	On
5	53	9	On
5	53	7	On
5	53	7	On
5	52	7	On
5	52	7	On

5	53	7	On
5	53	7	On
5	53	7	On
5	53	6	On
5	54	6	On
5	54	16	On
5	54	16	On
5	54	15	On
5	54	17	On
5	54	16	Off
5	52	15	Off
5	52	13	Off
5	50	14	Off
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5	50	14	Off
5	50	14	Off
5	50	13	Off
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5	49	13	Off
5	49	14	Off
5	48	13	Off
5	47	14	On
5	50	36	On
5	49	29	On
5	49	21	On
5	49	18	On
5	49	13	On
5	49	13	On
5	49	13	On
5	49	14	On
5	49	13	On
5	49	14	On
5	50	14	On
5	50	12	On
5	50	13	On
5	50	13	On
5	50	12	On
5	50	13	On

5	50	11	On
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