<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>On thin-clients and the cloud; can smartphones and tablets really reduce electricity consumption?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s)</strong></td>
<td>Corcoran, Peter M.; Andrae, Anders</td>
</tr>
<tr>
<td><strong>Publication Date</strong></td>
<td>2014</td>
</tr>
<tr>
<td><strong>Link to publisher's version</strong></td>
<td><a href="http://dx.doi.org/10.1109/ICCE.2014.6775918">http://dx.doi.org/10.1109/ICCE.2014.6775918</a></td>
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</tbody>
</table>
On Thin Clients & the Cloud

Can thin-clients reduce electricity consumption for CE-ICT?

Full details in our main study
Working Paper at:
http://vmserver14.nuigalway.ie/xmlui/handle/10379/3563

“Emerging Trends in Electricity Consumption for Consumer ICT” – A.Andrae (Huawei) & P.M.Corcoran (Nat. Univ. Ireland Galway)

Peter Corcoran, IEEE Consumer Electronics Magazine
What do we mean by ‘Clients’?

WHAT IS CE-ICT?
Everything is now ‘Connected’!

- Computers – Desktop, Laptop
- TV- Panels & Monitors
- Set-Top-Boxen (STB), Games Consoles
- Thin-Clients
  - Smartphones & Tablets
- Full details in our main study
  - Working Paper at:
    - http://vmsserver14.nuigalway.ie/xmlui/handle/10379/3563
    - “Emerging Trends in Electricity Consumption for Consumer ICT” – A. Andrae (Huawei) & P.M. Corcoran (Nat. Univ. Ireland Galway)
4 ways that CE-ICT devices use Electricity ....

- Directly from the mains supply
  - (Operational)
- Manufacturing electricity
  - (Embodied Energy)
- Network connection
  - (Core network + Radio Access Network)
- “The Cloud”
  - (Data Centers)
WHY IS CE-ICT SO IMPORTANT?

Don’t Industry & Business use more Energy?
Business/Consumer Data Traffic
Exabytes/Month
(Data courtesy Cisco VNI)
OUR MAIN STUDY
**Emerging Trends in Electricity Consumption for Consumer ICT** (2013)

- In 2010, Global Electricity use was 23,192 terawatt-hours (TWh), 6.5% above the 2009 level (International Energy Agency - 2013).

- Approximately 7-10% of this is due to CE-ICT depending on your information source(s).

- Working Paper at:
  - “Emerging Trends in Electricity Consumption for Consumer ICT” – A. Andrae (Huawei) & P.M. Corcoran (Nat. Univ. Ireland Galway)
Section 1

THE METRICS OF CE POWER

DIRECT, OPERATIONAL ENERGY
SmartPhone

- Typical Smartphone:
  - 2 KWhr per annum
  - $0.25 per annum

- Typical Tablet
  - 5-10 KWhr per annum
  - c. $1.00 per annum
Laptop Computer

- Typical Laptop:
  - 70 KWhr per annum
  - $8.00 per annum
TV Panel

- Plasma TV
  - 400 KWhr per annum
  - $50.00 per annum

- LCD TV
  - <180 KWhr p.a.
  - $20.00 per annum

- LED TV
  - <100 KWhr p.a.
  - $12.00 per annum
Game Console

- Usage more variable but typically from $20-$40 per annum
Desktop Computer

- Variability; older models consume more; latest models are much closer to laptops (100-150 KWhr)
- On its own
  - 300 KWhr per annum
  - $40.00 per annum
- With monitor
  - +100 KWhr p.a.
  - $50.00 per annum
Basic Lightbulb

- 60W Light Bulb
  - 10 hours per night
  - 220 KWhr per annum
  - $26.00 per annum

- LED Bulb – 7W
  - 25 KWhr per annum
  - $3.00 per annum
Today’s Question

CAN THIN CLIENTS REDUCE THE ENERGY USE OF CE-ICT?
New Devices Use Less

- Phones & Tablets replace Desktops & TVs
  - Improvements better than an order of magnitude
  - But a lot more ‘personal’ devices

- Older devices improve efficiency
  - Computers & TVs improved by a factor of 3 in last half-decade …
  - But longer lifecycle, particularly of TV means that the impact is spread over next 10 years, maybe longer
Why are thin clients important?

- Phenomenal Growth rate in Smartphones & Tablets in last few years
- Change in fundamental usage of CE-ICT
  - Many consumers now view TV/Movies on ‘small screen’;
  - New Media – youtube, facebook, Netflix, etc …
  - New Services – grocery shopping, games, social networks
- Tablets bring ICT from Desktop into Living Room, **challenging dominance of TV**
- **Disruptive Technology!**
But Thin Clients will drive Data Consumption ...

(Table courtesy Cisco VNI)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Laptop</td>
<td>1,145</td>
<td>1,460</td>
<td>2131</td>
<td>2,503</td>
<td>31%</td>
<td>5,731</td>
</tr>
<tr>
<td>Smartphone</td>
<td>35</td>
<td>55</td>
<td>150</td>
<td>342</td>
<td>81%</td>
<td>2,660</td>
</tr>
<tr>
<td>Smartphone (4G)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,302</td>
<td>--</td>
<td>5,114</td>
</tr>
<tr>
<td>Tablet</td>
<td>28</td>
<td>405</td>
<td>517</td>
<td>820</td>
<td>113%</td>
<td>5,387</td>
</tr>
<tr>
<td>Gaming Console</td>
<td>--</td>
<td>244</td>
<td>317</td>
<td>--</td>
<td>--</td>
<td>NA</td>
</tr>
<tr>
<td>Mobile Phone</td>
<td>1.5</td>
<td>1.9</td>
<td>4.3</td>
<td>6.8</td>
<td>--</td>
<td>31</td>
</tr>
</tbody>
</table>

- Data use in MB per month; note the **CAGR rates of 81% and 113%** for smartphones & tablets;
- Tablets will consume as much “Network Data” as Laptops by 2017 – 2x the consumption of today’s laptops; but there will be **a lot more** tablets & smartphones …
Growth in Numbers = Big Growth in Data Traffic

- **Today (2013)** -
  - c. 600 Million Laptops

- **Tomorrow (2017)** –
  - c. 2,000 Million tablets (+ c. 1000 Million Laptops)
  - c. 4,000 Million smart-phones (conservative?)

- **TV Panels are also becoming “connected”**:  
  - Smart TV
  - Add-on connectivity: Boxee, Apple-TV, many others ...
Current Energy Balance (2012 data)

- ½ of Energy is direct consumption by Device
- c. 1/6 each due to Manufacturing (LCA), Networks & Data Centers
WHAT IS LATEST GLOBAL STATUS?

(Q3 2013)
Some Good News – Devices

• Improving Devices
  • TV Panels making transition to low-power LED technology (2012-2014) – 50%+ energy savings
  • Set-top boxen; Energy Star estimates 40 TWhr/yr

• Shrinking Markets *(due to adoption of Thin Clients!)*
  • Desktop PC market down significantly (>10%) in 2013
  • TV Panel market also down in 2013
Some Good News – Data Centers

- Koomey recently (2012) revised downwards estimates for global data centers by 25% to c.240 TWhr/yr in 2010.
- But recent development of cloud services suggests strong future growth.

Jonathan Koomey is a Research Fellow at Stanford University, worked for more than two decades at Lawrence Berkeley National Laboratory, and has been a visiting professor at Stanford University, Yale University, and UC Berkeley’s Energy and Resources Group.
But Strong Data Growth Projected
[Cisco VNI 2013- mobile data]
(Energy) Growth in Wireless Access
CEET 2013

The Power of Wireless Cloud (2013 Whitepaper)
Thin Clients ➔ Expanding Radio Access Networks (RANs)

- 100 TWhr/yr to power ‘base stations’ in 2013
  - (Nokia Solutions and Networks, 2013)
- LTE Network: 20+ times more power than WiFi?
  - (Huang, 2012; practical study on ‘real’ networks)
- Practical LTE Nets: only 10% even for heavy use
  - (EU EARTH project, 2012)
- 2013 is THE Big ‘Roll-Out’ for LTE/G4 Networks …

Key Question –

Can LTE provide more efficient RAN?
Main study conclusions

Full details in our main study

Working Paper at:

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“Emerging Trends in Electricity Consumption for Consumer ICT” – A.Andrae (Huawei) & P.M.Corcoran (Nat. Univ. Ireland Galway)
Conclusion 1 from our Study

- 3 Scenarios –
  - (i) Optimistic, (ii) Most Likely & (iii) Pesimistic
- All 3 suggest that the balance between device & network will shift in the same way …
- Today –
  - 50% Device : 35% Network + Cloud
- Tomorrow (5 Years) –
  - 33% Device : 50% Network + Cloud
(Ratios are likely conservative given emerging 2013 trends)
Conclusion 2 from our Study

(Table shows % of Global total Electricity use – assumes 3% annual growth)

- Estimated CAGR of 3% for Global electricity consumption (conservative? Recent data suggest could be closer to 5%?)
- Worst case based on 2008++ economic behavior (very unlikely)
- The Future is still in our hands …
QUESTIONS
Business/Consumer Data Traffic
Exabytes/Month

(Data courtesy Cisco VNI)
The Future is still in our Hands…

**Figure 3(b):** Percentage of global electricity consumption due to CE-ICT for best/expected/worst case scenarios.
Final Numbers from our Study

Figure 3(a): Graph of electricity consumption in TWh/yr for best/expected/worst case scenarios.

- The Future is still in our Hands …
Final Numbers from our Study

Table 16(a): Projections of total electricity consumption in (TWh/yr); based on the best/expected/worst case scenarios for devices (direct consumption and manufacturing energy), networks and data centers, as outlined throughout section 5.

<table>
<thead>
<tr>
<th>TWh/yr</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Case</td>
<td>1,817</td>
<td>1,832</td>
<td>1,858</td>
<td>1,895</td>
<td>1,929</td>
<td>1,982</td>
</tr>
<tr>
<td>Expected</td>
<td>1,817</td>
<td>1,923</td>
<td>2,051</td>
<td>2,200</td>
<td>2,358</td>
<td>2,547</td>
</tr>
<tr>
<td>Worst Case</td>
<td>1,817</td>
<td>2,045</td>
<td>2,317</td>
<td>2,643</td>
<td>2,998</td>
<td>3,422</td>
</tr>
</tbody>
</table>

- Totals for CE-ICT Electricity Consumption (2012-2017)
## Energy Distribution

**Direct Device Consumption of Electricity**

- **ICT Energy (2011)**

<table>
<thead>
<tr>
<th>Device</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desksops</td>
<td>14.4%</td>
</tr>
<tr>
<td>Monitors</td>
<td>6.7%</td>
</tr>
<tr>
<td>Laptops</td>
<td>7.4%</td>
</tr>
<tr>
<td>Smartphones</td>
<td>0.7%</td>
</tr>
<tr>
<td>Tablets</td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Client Total</strong></td>
<td><strong>29.5%</strong></td>
</tr>
</tbody>
</table>

- **TV Energy (2011)**

<table>
<thead>
<tr>
<th>Device</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>48.1%</td>
</tr>
<tr>
<td>TV STB</td>
<td>8.7%</td>
</tr>
<tr>
<td>TV GC</td>
<td>6.7%</td>
</tr>
<tr>
<td>A/V Receiver</td>
<td>4.7%</td>
</tr>
<tr>
<td>DVD/Blueray</td>
<td>2.4%</td>
</tr>
<tr>
<td><strong>Client Total</strong></td>
<td><strong>70.5%</strong></td>
</tr>
</tbody>
</table>
HOW TO SAVE THE PLANET?

SOME THOUGHTS FOR THE COMMUNICATIONS INDUSTRY
Focus is on Radio Access Networks

- As devices become more energy efficient & more connected; drives energy use ‘into the cloud’
- Huge growth in consumer network traffic – can’t put “iPhone Genie” back in bottle;
- RANs become a growing energy ‘sink’; (but engineers love solving difficult problems!)
- Next Generation RANs an ‘Unknown’ factor?:
  - How will LTE/G4 work on a global scale in practice?
  - Rural & Urban deployment strategies?
  - Efficiency Vs alternative technologies? WiFi/WiMax? HSDPA?
New problems – New Challenges!

- Energy use data for Comms Industry is not very transparent/accessible (my experience?)
  ...  
  ◦ Can lead to unwarranted press coverage, partly due to industry lack of transparency;
    • e.g. iPhone uses more electricity than 2 Fridges (Untrue!)

- There is a need to think outside the box
  ◦ Solar-powered cellphone towers?
  ◦ Distributed data/service buffering? [Smart Home Cache?]

- Remember, Engineers love a Challenge!
Conclusions?

- Phones & Tablets replace Desktops & TVs
  - Phone & Tablets sales growing exponentially
  - Desktop & TV market size declining
  - Laptops replacing desktops
  - TV’s significantly more efficient in just a few years: 2012-2014 [Transition from Plasma to LED-TV]

- Can we expect an order of magnitude drop in device electricity?