Measurement of wood energy assortments in Sweden

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Increasing consumption of wood energy assortments – now approx 10 milj m$^3$ per year

Roundwood  Small trees  Tops and branches

Logging residues
A new measurement law in 2015

- Will include all assortments, also energy, but only when sold from the forest owner.
- Only "evaluated" methods and equipment may be used.
- Measuring companies must have internal control and show that accuracy requirements are fulfilled.

This triggers more focus on the development of techniques and methods for measurement of energy assortments.
Organisation of timber measurement in Sweden

Government – Timber Measurement Act

National Board of Forestry – measurement regulations

Operational organisations (private sector)

National board of sellers and buyers
- SDC
  - Timber accountancy

Regional boards of sellers and buyers
- Syd Qbera
  - Timber measurement associations
- Nord

Two of SDCs departments

Control of timber measurement (VMK)
- Monitors the quality of timber measurement
- Authorises of timber measurement companies
- Approves measurement equipment

Development of timber measurement (VMU)
- Development projects of national interest
- Measurement instructions
Organisation of wood measurement in Sweden

Three regional Timber Measurement Associations

- VMF Nord
  Umeå
  280 Employees

- VMF Qbera
  Falun
  375 Employees

- VMF Syd
  Jönköping
  315 Employees

Four closely collaborating, private, non-profit companies.

- SDC – the IT company for the Swedish forestry sector, 115 employees

- VMU and VMK, two of SDC’s departments
Wood energy from the forest
Approx 10 milj m³

Wood energy terminals
Approx 250

Consumers
100-200 heating plants,
20-30 pulp mills etc

Measurement
Sale step 1-2

Measurement
Sale step 1-2-3

Measurement
Sale step 3

Wood energy companies
Sale step 1-2

Timber purchasers
Sale step 1

Forest owners

20 %

65 %

15 %
# Assortments / measurement method / trading units

<table>
<thead>
<tr>
<th>Roundwood</th>
<th>Small trees, tops and branches, recycled wood</th>
<th>Chipped materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pile measurement (stack measurement)</strong></td>
<td><strong>Weight</strong> + <strong>conv.factor</strong></td>
<td><strong>Loose volume</strong></td>
</tr>
<tr>
<td>m³ sub</td>
<td><strong>Weight</strong></td>
<td><strong>Weight + moisture content</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Weight</strong> + <strong>moisture content from chipped sample piles</strong></td>
<td><strong>Dry ton or MWh</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dry ton or MWh</strong></td>
<td><strong>m³ loose</strong></td>
</tr>
</tbody>
</table>

**m³ sub** for Roundwood and **m³ loose** for Chipped materials.
Most roundwood for energy is measured as manual measurement of piles on trucks

Volume under bark: Length x Width x Height x Estimated wood volume percent

Four alternatives:
1. Timber Measurement Association at “equipped” measurement station
2. Remote measurement using cameras
3. Measurement by truck drivers
4. Weight scaling, conversion to volume
Control (check scaling) of pile measurement is done as log-by-log measurement.
Remote measurement using cameras – installation at SCA’s terminal in Sundsvall

- Cameras for measurement of log length and pile height
- Cameras to see end faces of the piles, for id-marking, quality etc

All cameras can be used to determine solid volume percent, species etc
Remote measurement – example with nine cameras

Six cameras for pile end faces. Used for estimation of wood volume percentage, rot, marking etc.
The driver and the scaler

The driver

All photos displayed on a screen.
The driver approves quality of the photos.
He is informed if there is a sample for log-by-log measurement.

The scaler

Measurement on the screen.
Can be done from another place or at another time.
Measurement by truck drivers

Daily conversion factors weight/volume, So far only used for pulpwood

Both alternatives often less accurate compared to trained scalers
- Roundwood: solid volume
- Chips: loose volume
- Small trees or tops and branches: no volume

Pile measurement

Control measurement

• Roundwood: solid volume
• Chips: loose volume
• Small trees or tops and branches: no volume
Energy assortments – we need weight scaling - always and everywhere

We need to follow Finland and North America
Weight scaling – ongoing studies in Sweden

Grapple weighing in forwarders or timber trucks

Dynamic weighing

Influence of the operator?

Sensitivity tests
Purchase of tops and branches by dry tons. Guesstimate of moisture content using cameras, chipped samples for MC determination
Chipped forest fuel

- Roundwood
- Whole trees
- Tops and branches
- Stumps
- Energy forest
- Bark
- Saw dust
- Recycled wood

Which trading unit? Volume \((m^3)\) loose volume in containers) or dry tons or energy content \(\text{(MWh)}\)?

Measured when delivered in containers on trucks or railroad
Measurement of loose volume might be phased out and replaced by dry tons

Problems

- Easy measurement but difficult to perform controls
- A trading unit that depends on:
  1. Transport distance
  2. Chipping equipment

Today’s manual measurement. Height per section.

"pre-measured" containers

Control: Laser measurement at many points
Dry tons or MWh requires determination of moisture content

Which measurement accuracy will we have given prerequisites like:

- Sampling method
- Number of samples
- Size of a sample
- Assortment
- Chipping equipment
- Method when loading/transporting
- Season (time of the year)

Measurement accuracy a result of statistical analyses
Sampling for moisture content - the key to dry tons or MWh

Near Infra Red (NIR) probe

Result directly

Mechanical probe

Material for analysis of more than moisture

Manual sampling at scaling station

or after off-loading
Manual sampling most common

Manual sampling at a measurement station. Use a correct shovel.

Sampling after off-loading. Commonly done by the drivers, or by the personnel at the heating plants.
An example of a field laboratory for MC-analyses

- A mobile container with drying ovens
- Installed at a couple of small measurement stations
Example on the result of bad sampling

- VMU = 20 well distributed MC samples
- Part = sampling by the driver

Deviation in quantity (dry tons)

17 truck loads of chipped logging residues
### Measurement accuracy (dry weight) for a contract, given a certain sampling, chipped logging residues

<table>
<thead>
<tr>
<th>Number of sampled trucks</th>
<th>Samples per truck</th>
<th>Number of trucks in the same contract</th>
<th>Mean error for the contract %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>4,5</td>
<td>5,5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3,4</td>
<td>4,1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2,9</td>
<td>3,4</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
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<td>-</td>
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<td>-</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Red circle: will not fulfill accuracy demands
- Yellow circle: will fulfill accuracy demands with 95% probability
- Green circle: will fulfill accuracy demands with 99% probability
Measurement of chipped materials
four "scenarios"

Loose volume
\( m^3_{\text{loose}} \)

Weight + moisture content
Dry tons or MWh

Big station
- Measurement bridge
- Control on site
- Quality can be assessed

Small site without facilities
- "Measure" when loading
- Pass control site when sampled
- No quality assessment

Big station with MC-equipment
Alt. for MC sampling:
1. NIR probe
2. Mechanical probe
3. Measurement bridge
Other equipment:
- Lab for MC samples
- Weight scale

Small site without facilities
- MC samples after off-loading
- Samples transported to MC-lab
- Weighing using crane or in-built load cells

Basic demands for loose volume
- "Pre-measured" containers
- Control using special equipment

Basic demands for weight + MC content
- Approved weighing
- Control MC samples after off-loading
The future,

Well, in 1984 the Swedish Timber Measurement Council declared:

"All energy assortments should be measured and traded based on their dry weight"

That might come in the future!
Pulpwood or roundwood for energy: Two main areas for development

Measurement in photos

**Krokom**
Should be cheaper
Small measurement stations can be open 24/7

Automatic measurement - Mabema

**Braviken**
Should be better and quicker
Big measurement stations, maybe also for sawlogs

Finland has Modus and AVM-stations
Automatic measurement of piles on trucks

- Laser triangulation (like in a log scanner)
- Developed by Mabema in Linköping

Our biggest development project
Laser triangulation for solid volume

Cameras from three sides and from a certain angle for description of pile end face. In total six sets of cameras and lasers.

Accuracy goal: standard deviation per pile < 6 %
The situation in 5-10 years?

Measurement in photos
- Many of the smaller measurement stations, incl wood energy terminals
- Also at bigger measurement stations for prolonged opening hours

Automatic pile measurement
- Many of the pulpmills
- Some sawmills (eg mills sawing standard lengths)
The four alternatives to measure wood volume under bark

<table>
<thead>
<tr>
<th>TMA at ”equipped” measurement station</th>
<th>Remote measurement using cameras</th>
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</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td><strong>Positive</strong></td>
</tr>
<tr>
<td>Well trained personnel</td>
<td>Well trained personnel</td>
</tr>
<tr>
<td>Can be TMA</td>
<td>Risk for slightly reduced</td>
</tr>
<tr>
<td></td>
<td>accuracy</td>
</tr>
<tr>
<td><strong>Negative</strong></td>
<td>Low cost</td>
</tr>
<tr>
<td>High cost</td>
<td>Width of truck (pile length)</td>
</tr>
<tr>
<td>Limited opening hours</td>
<td>cannot be measured</td>
</tr>
<tr>
<td></td>
<td>Can be TMA</td>
</tr>
<tr>
<td></td>
<td>Flexible opening hours,</td>
</tr>
<tr>
<td></td>
<td>can be 24/7</td>
</tr>
</tbody>
</table>

| Measurement by truck drivers         | Weight scaling, conversion to   |
|--------------------------------------| volume                          |
| **Positive**                         | **Positive**                    |
| Low cost                             | Weight ”for free” when loading  |
| No need for meas.station             | Low accuracy for conversion     |
|                                     | factors                         |
|                                     | Individual differences          |
|                                     | Much log-by-log measurement for|
|                                     | conversion accuracy and/or      |
|                                     | controll                        |
|                                     | Difficult to organise control   |
|                                     | Lack of control procedures for  |
|                                     | crane weight                    |
| **Negative**                         |                                |
| Less accurate                        |                                |
| Individual differences               |                                |
| Difficult to organise control        |                                |
Moisture content measurement with NIR-probe

The probe can be freely positioned within the container

Five installations in Sweden - more will probably follow
Mechanical probe for MC-sampling

- Three (old) installations in Sweden
- Press down to wanted depth, filled when turning back