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# **Co-pelletization of sewage sludge and agricultural wastes**

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## Agricultural residues as a source of energy

Turkey has great agricultural potential - 28.05 million ha arable land.

Total amount of agricultural solid waste is about 50–65 million tonnes.

Cotton



Olives



Wheat



## Characteristics of selected agricultural residues

| Type of waste   | Moisture % | Ash % d.m. | Volatiles % d.m. | C     | H     | O % d.m. | N    | S     | HHV MJ/kg |
|-----------------|------------|------------|------------------|-------|-------|----------|------|-------|-----------|
| Corn cob        | 0          | 6.4        | n.d.             | 45.53 | 6.15  | 41.11    | 0.78 | 0.13  | 17.81     |
| Barley straw    | 15         | 4.9        | n.d.             | 46.8  | 5.53  | 41.9     | 0.41 | 0.06  | 18.79     |
| Oat straw       | 15         | 4.9        | n.d.             | 46    | 5.91  | 43.5     | 1.13 | 0.015 | 18.09     |
| Wheat straw     | 7.75       | 6.22       | 15.68            | 46.95 | 5.355 | 1.05     | 0.51 | 0.22  | 18.5      |
| Grape waste     |            | 7.5        | 67.9             | 50.0  | 6.0   | 34.4     | 2.0  | 0.1   | 22.1      |
| Almond shells   |            | 1.2        | 79.3             | 49.2  | 6.0   | 43.4     | 0.2  | 0     | 19.7      |
| Sunflower straw | 40         | 3          |                  | 52.9  | 6.58  | 35.9     | 1.38 | 0.15  | 20.82     |
| Olive oil waste |            | 7.1        | 77.3             | 48.9  | 6.2   | 36.2     | 1.4  | 0.2   | 21.6      |

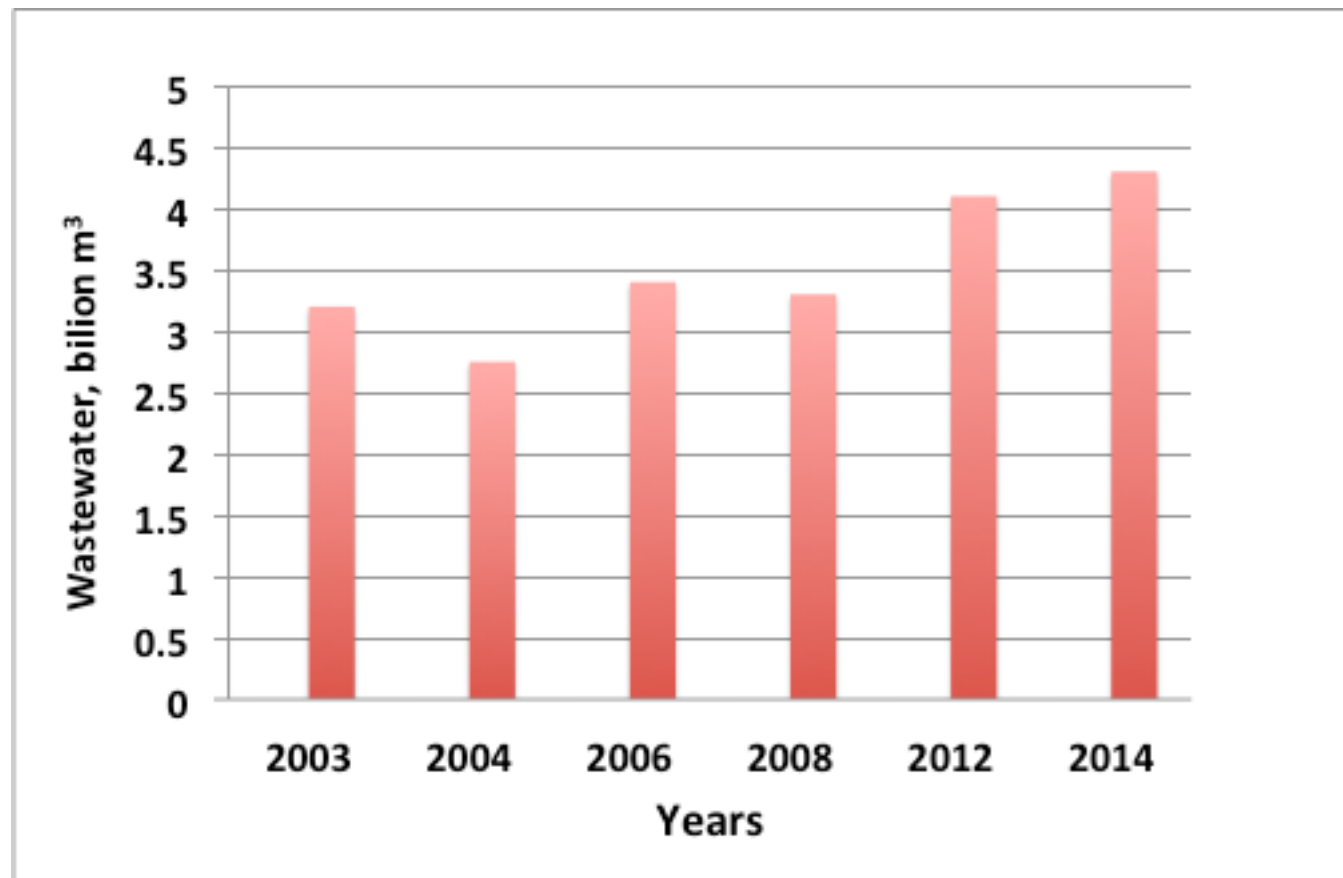
## Animal waste

| <b>Animal waste</b> | <b>Waste quantity tonnes/year</b> | <b>Total dry manure tonnes/year</b> | <b>Available dry manure tonnes/year</b> | <b>LHV MJ/kg</b> |
|---------------------|-----------------------------------|-------------------------------------|-----------------------------------------|------------------|
| Cattle              | 127,654,932                       | 16,211,033                          | 10,535,172                              | 17.01            |
| Sheep               | 24,558,323                        | 6,139,581                           | 758,146                                 | 11.08            |
| Poultry             | 7,731,694                         | 1,932,924                           | 1,913,594                               | 12.08            |

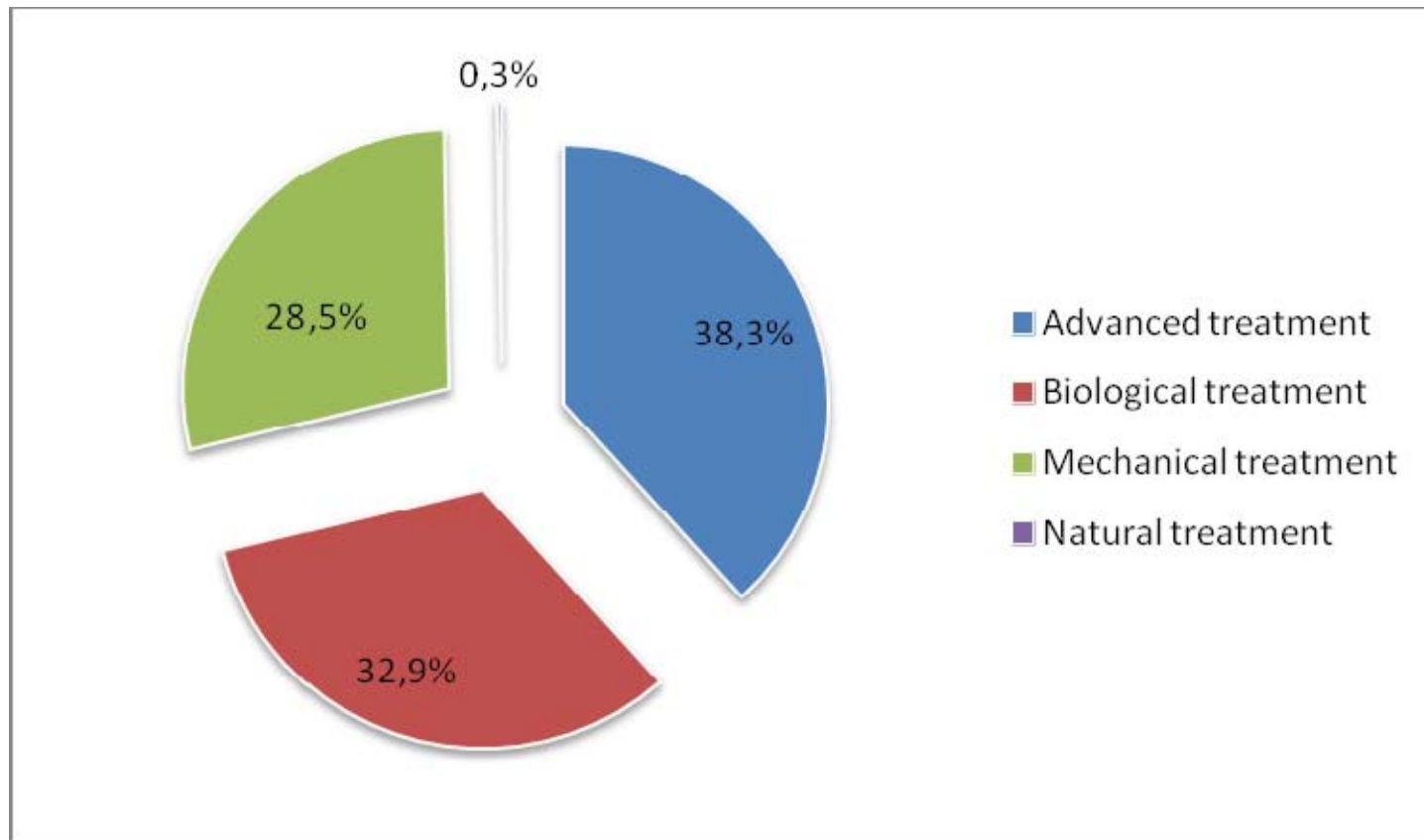




## Production of wastewater in Turkey



## Methods of treatment in WWTP in Turkey





## **Technical and technological aspects of the production of fuel from waste and biomass**

However, it is not always possible to use an already existing technology and the development of a new one requires solving a range of issues, some of which are as follows:

- selection of fuel components which influence the properties, energy generation parameters in particular, including the selection of binding additives,
- selection of a waste forming method,
- adjustment of working parameters of the forming device so as to achieve the proper quality of the product.

## Selected properties of components of pellets

| Parameter       | Unit   | Sewage<br>Sludge<br>(SS) | Olive<br>Waste<br>(OW) | Animal<br>Waste<br>(AW) |
|-----------------|--------|--------------------------|------------------------|-------------------------|
| Water           | %      | 85.00                    | 65.00                  | 90.97                   |
| HHV             | MJ/kg  | 11.22                    | 18.79                  | 8.85                    |
| Voltaire matter | % d.m. | 35.03                    | 48.18                  | 24.84                   |
| Ash             | % d.m. | 41.02                    | 22.02                  | 9.52                    |





## Type of pellets

In order to identify the pellets, individual symbols were attributed to them:

**SOW** – pellets based on the sewage sludge and olive waste

**SAW** – pellets obtained from the sewage sludge and animal waste

The studies covered pellets with the sewage sludge content of 20% (SOW20, SAW20) and 30% (SOW30, SAW30) and pellets made of SS only.



## Some parameters of pellets

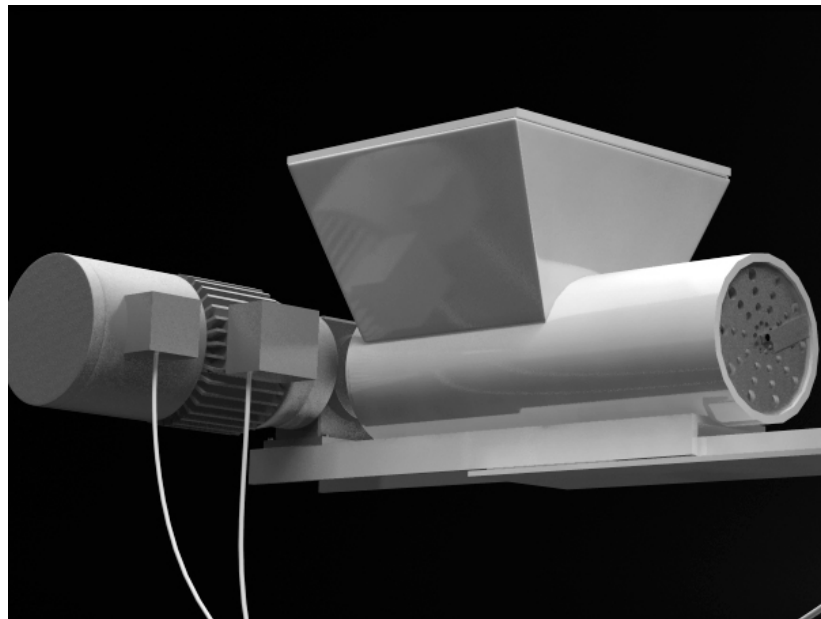
The research involved energy properties:

- **high calorific value** (HHV)
- the ash, the volatile matter content and moisture
- the ultimate analysis

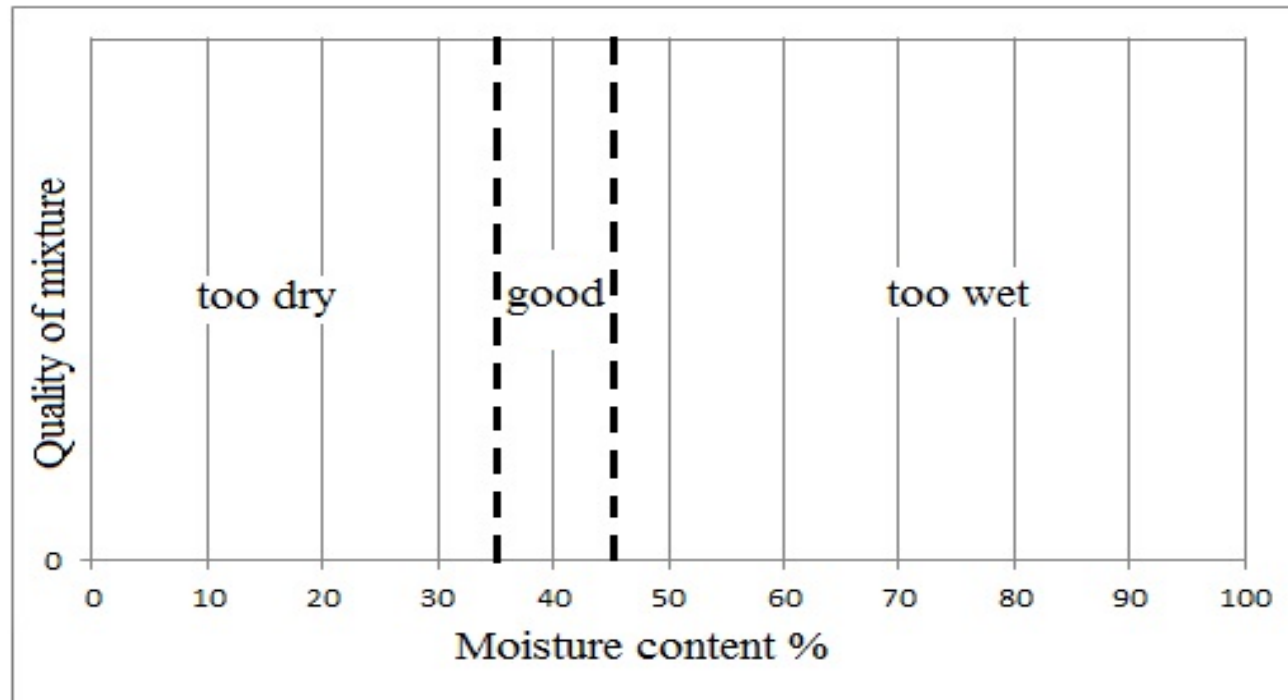
and physical properties:

- drop strength (according to the PN-G-04651),
- water - resistance (PN-G-04652),
- absorbance (PN-G-04652).

# Forming device



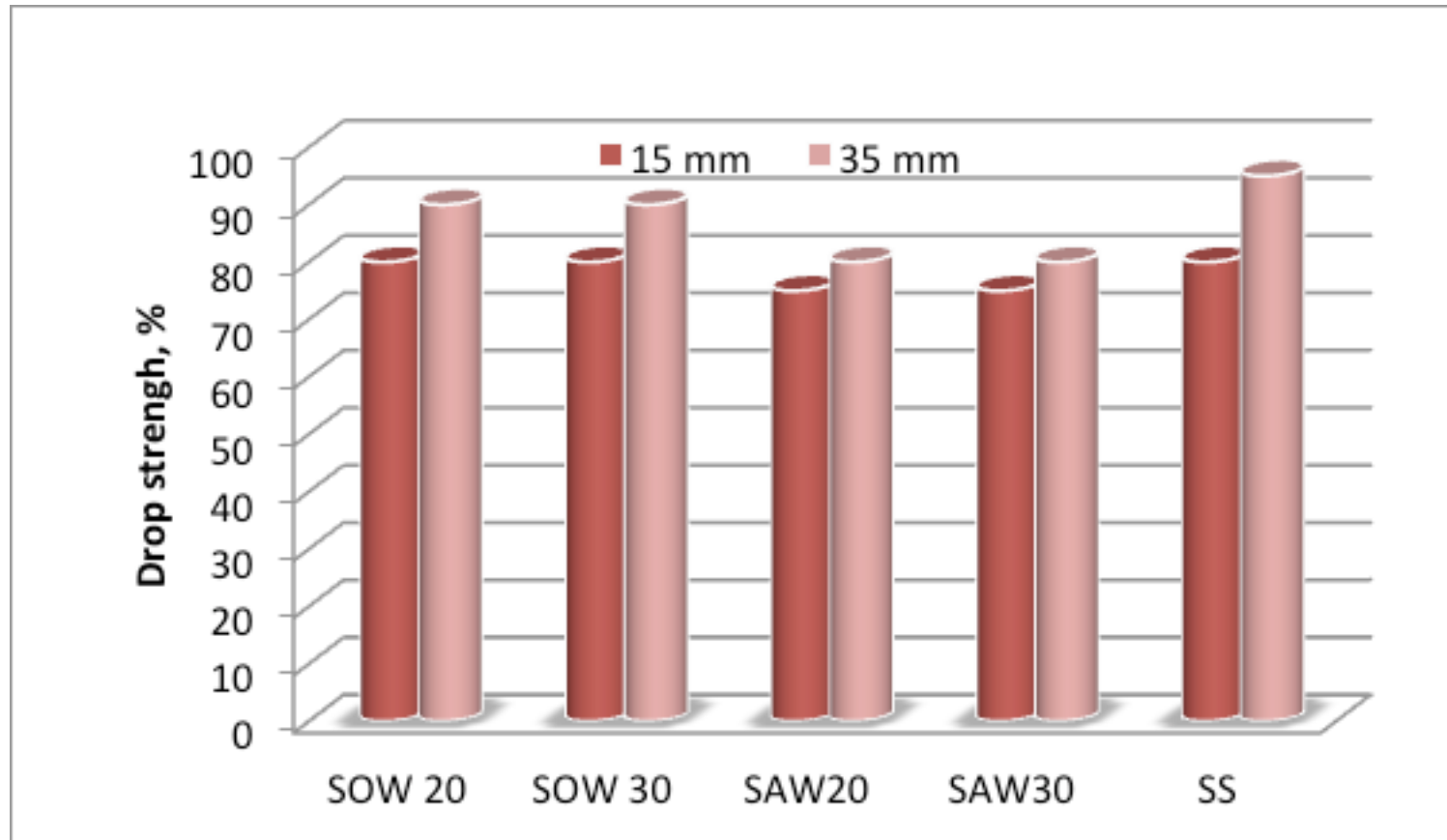
## The influence of the moisture content of the mixture being formed on the quality of fuel



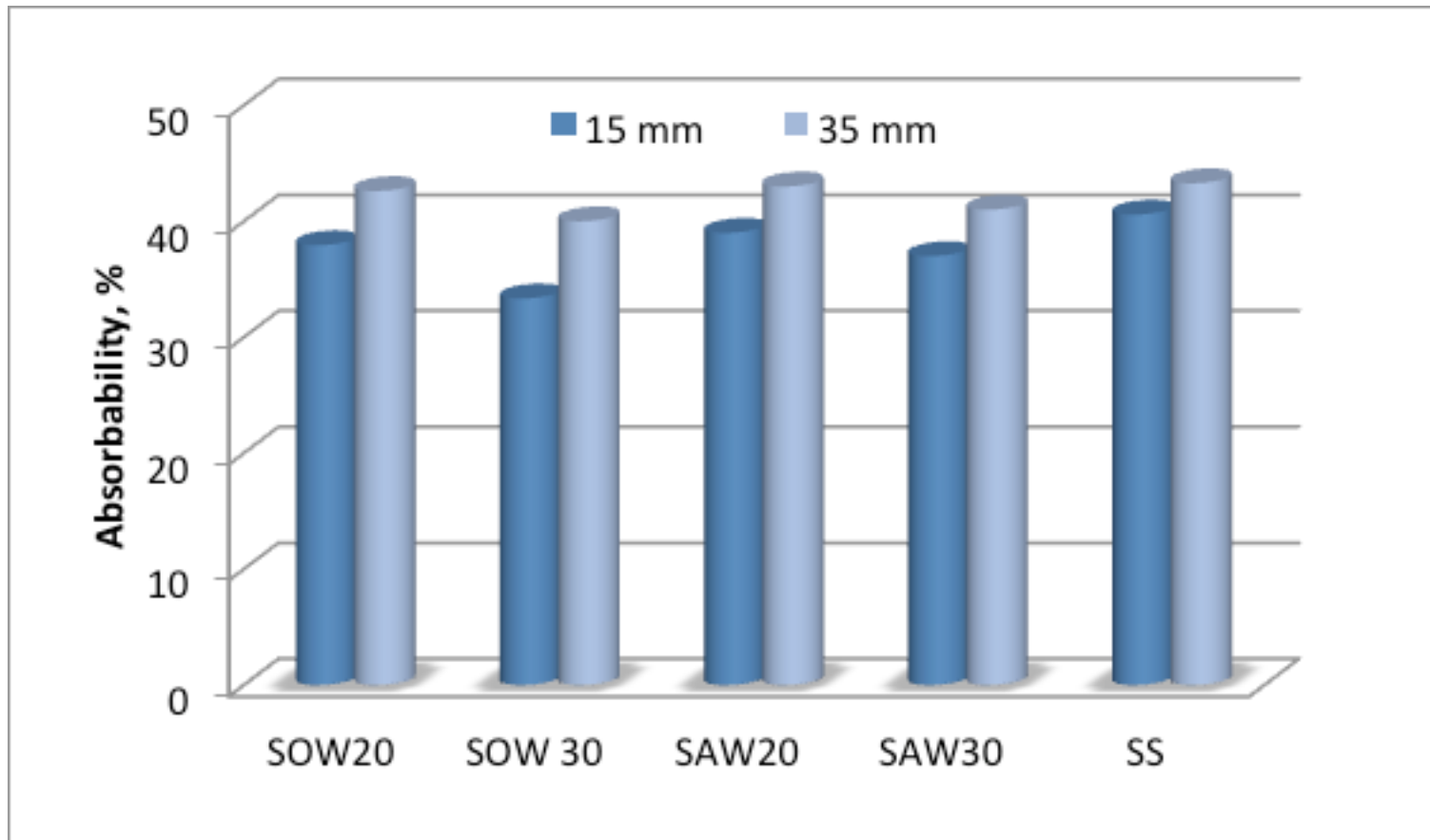
# Energy properties of pellets

| Parameter              | Unit   | SOW20 | SOW30 | SAW20 | SAW30 | SS    | Hard coal |
|------------------------|--------|-------|-------|-------|-------|-------|-----------|
| Water                  | %      | 5.89  | 6.22  | 6.05  | 5.18  | 5.09  | 5.0-10.0  |
| Voltaire matter        | % d.m. | 30.17 | 29.73 | 30.78 | 29.67 | 37.88 | 25.0-40.0 |
| Ash                    | % d.m. | 39.65 | 30.92 | 41.91 | 42.69 | 45.73 | 8.5-11.3  |
| LHV                    | MJ/kg  | 12.41 | 14.52 | 10.78 | 8.58  | 10.08 | 23.7-28.3 |
| HHV                    | MJ/kg  | 13.41 | 15.80 | 11.85 | 9.46  | 11.03 | 26.0-28.3 |
| Elementary composition |        |       |       |       |       |       |           |
| C                      | % d.m. | 30.79 | 35.81 | 30.79 | 24.01 | 27.24 | 76.0-87.0 |
| H                      |        | 4.49  | 5.16  | 4.211 | 3.47  | 3.77  | 3.5-5.0   |
| N                      |        | 1.54  | 1.38  | 1.8   | 1.71  | 2.11  | 0.8-1.5   |
| S                      |        | 0.55  | 0.79  | 1.98  | 0.94  | 1.97  | 0.5-3.1   |

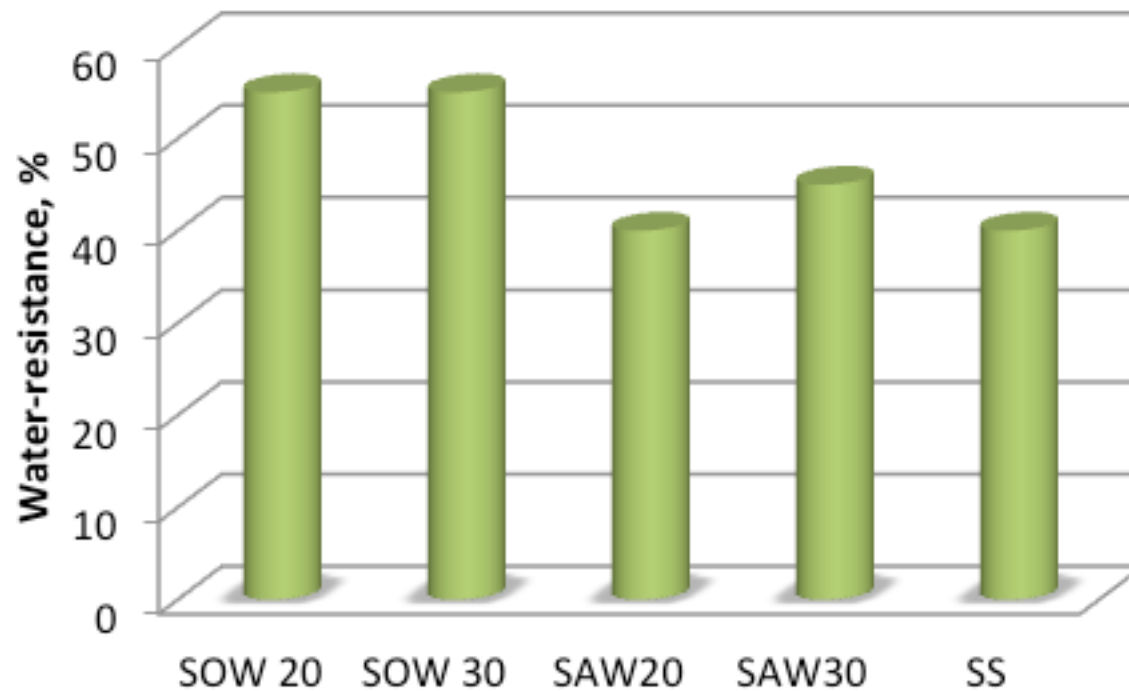
## Drop strength of pellets



## Absorbability of pellets



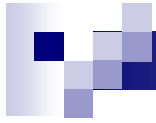
## Water-resistance of pellets (diameter 15 mm)





## Conclusions

- The developed technology of pellet production from residues consists in initially mixing sewage sludge with other waste in set proportions and then forming it into pellet and drying.
- The processed and treated waste in the form of pellet allows for storing it without leading to secondary environment pollution and the assumed form of fuel facilitates transport, which increases potential for its use.
- The tests for physical properties demonstrated that pellets may be subjected to mechanical handling operations which are connected with their transport, loading and unloading, etc.
- However destructive effects of water on drop strength were observed for all test pellets. The fuels are characterised by high water absorbability and they should be protected against atmospheric precipitation for short-time intermediate storage.



**Thank You for Your attention**