# FULL SCALE IMPLEMENTATION OF LAB TESTS' RESULTS ON IMPROVE SLUDGE DIGESTION – NOWY SACZ CASE STUDY

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**ABSTRACT**
The paper describes practical results of long-term laboratory studies completed to estimate a technically feasible conditions of retrofitting of existing sludge disposal system for an energy recovery improvement. The pathway from lab studies and simulations to full scale investments have been shown with a special emphasis on application of specific procedures. Especially how to predict a digestion time for sludge of specific composition. Investigations completed at the Nowy Sacz WWTP, resulted in practical implementation to be used during the design of upgrading and extension of the digestion and energy recovery system at the plant
It was proved that mixing of primary and waste activated sludge(WAS) at the 1:1 VSS ratio provides the optimum conditions for process performance and application of proposed calculation procedures was adopted by design team. Finally some basic economical simulations were presented to illustrate overall feasibility of these changes. This paper summarizes combined scientific and design effort of last five years.

**KEYWORDS**
Sludge processing, sludge digestion, biogas, energy recovery, WWTP upgrading

## INTRODUCTION

Tests described in the paper were performed at the Nowy Sacz WWTP, their reason and scope were described in papers published in Joint Polish Swedish Reports series (*Kurbiel&Rybicki 2000, Cimochowicz-Rybicka&Rybicki 2003*). Authors focused on general problem whether separate processing of primary and wasted activated sludge is as effective as combined one. The first tests were conducted due to reported problems with dewatering of aerobically stabilized WAS, later it was noticed that aerobic stabilization caused consumption rather than generation of an energy. On the other hand a digestion usually creates stabilized sludge of better dewatering characteristics besides an energy consumed for sludge mixing and heating is lower then energy contained in a methane generated in digesters. So it was assumed that with the process being conducted in close-to-optimum conditions significant surplus of energy produced over energy consumed should be observed. The main reason of this case study was to check whether change of process from combined aerobic+anaerobic stabilization to anaerobic digestion only would led to energy savings. Simultaneous effects expected to obtain were: better dewatering characteristics and decrease of a polyelectrolyte consumption (for dewatering) and finally reduction of sludge volume for ultimate utilization.

The laboratory method supporting the study and (later) a design process has been a respirometric batch test, which appeared to be the most precise method for determination of digestion parameters. The method applied biogas generation, which remains proportional to organic matter decomposition. The objective of the laboratory study was to estimate a technically feasible digestion time for raw sludge of a different composition. Additionally, the progress of a sludge digestion process was examined in the sludge samples collected at the Nowy Sacz WWTP. The obtained results will provide valuable information that can be used during the discussion on upgrading and expansion of the existing sludge digestion system at the plant. Moreover, the results can serve as a tool in developing a technological guideline for design of a complete sludge processing system, including a new digester. Details of these lab tests were presented by authors previously (*Cimochowicz-Rybicka&Rybicki 2003*).

## APPLICATION OF RESULTS IN DESIGN PRACTICE

### Changes in process' layout

Detailed characteristics of two process schemes which were examined was presented by Kurbiel and Rybicki (*Kurbiel&Rybicki 2000)*; finally a new layout proposed by authors has been simplified in Fig 1. below.

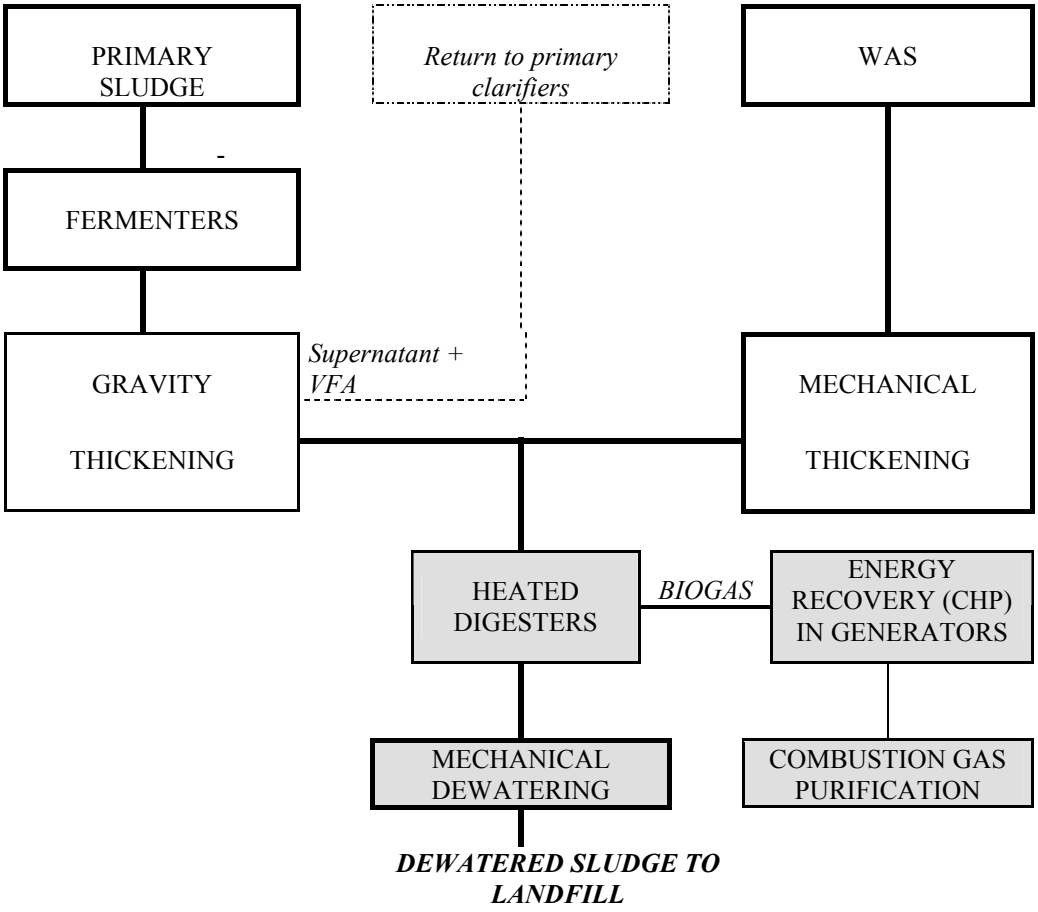


**Figure 1.** WWTP Nowy Sącz – sludge processing layout – proposed improvements.

**Determination of proper SRT**

Determination of proper retention time in digestion chambers is of crucial importance in design optimization of these facilities. It is especially difficult, when there is no 'real sludge'. In this specific case, the sludge was obtained in small portion as continuous operation of the plant was still based on a pattern: digestion of primary and simultaneous aerobic stabilization of a WAS. A procedure of estimation of these parameters for predicted mixture of a primary sludge and WAS has been proposed as based on cumulative curves of a gas production for digestion without an inoculation. Based on plotted curve VSS content vs. time the net length of the start-up ('yield') phase was estimated , similarly a length of effective gas production phase ('decay') was estimated. The procedure for mixed sludges (1:1 proportion) is shown in Fig.2. for 2:3 proportion. The maximum theoretic effective gas production period was estimated as an interval between intersection point of tangent to a VSS content curve with a time-axis and a final point of an effective gas production period , which led to general SRT 23 days adopted for design purposes.

The procedure for this proportion was illustrated in Fig.2. Duration of a start-up period was estimated as 27 days but it must be recognized that these tests were completed without an inoculation. The effective digestion period has been determined as 23,5 days. If the digestion time was extended over this value it did not resulted in better stabilization of sludges. This value was adopted for a real design

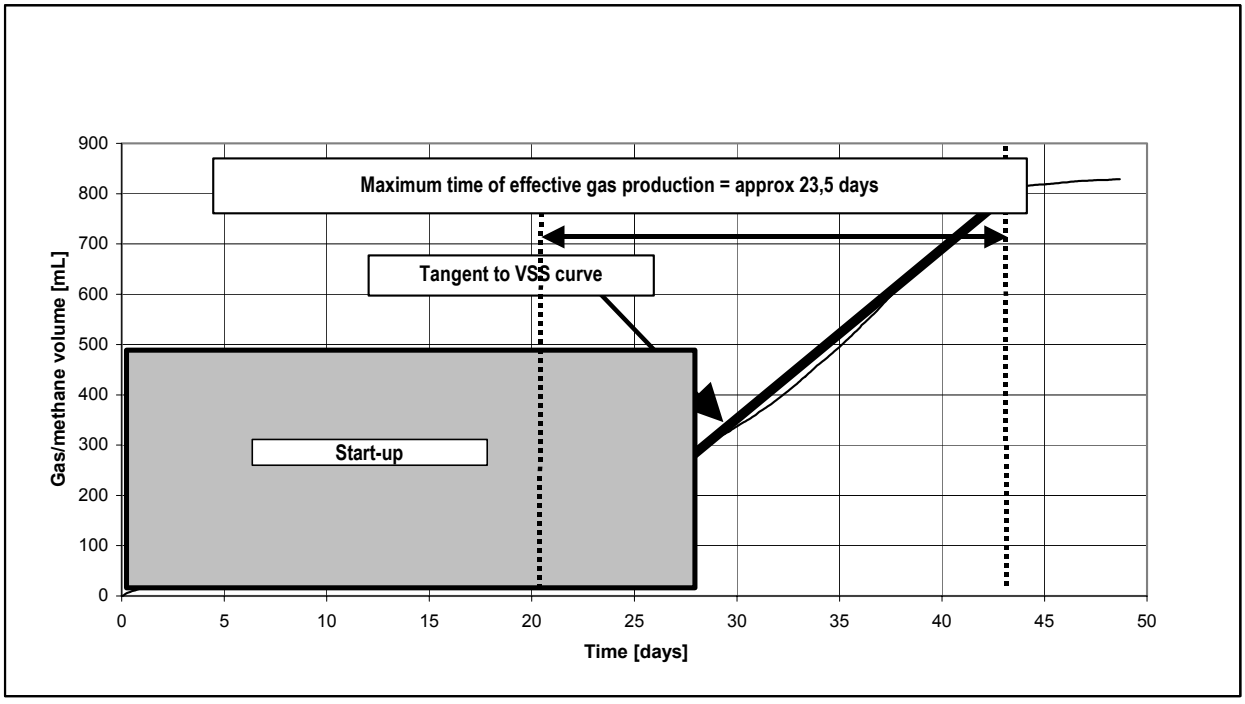


**Figure 2.** Determination of a retention time for design purposes. Mixed sludges : primary and WAS (1:1 proportion).

**TECHNICAL SOLUTIONS**

Lab tests proved that common digestion of primary and WAS sludges is technically feasible but requires some capital improvements of the plant. Basing on our tests it was decided by the Utilities (Sądeckie Wodociągi) that a design a capacity of the biogas generation system will be 2000 stdm$^3$/day with possible extension of a gas production to maximum value approx. 28000 std m$^3$/day.

Results of tests were approved than adopted as a process calculations by a designer (ECON Kielce, Poland).

Following new units will be completed:

- New digestion chamber, 3000 $m^3$ volume;
- New boiling system for this (new) chamber;
- New combined heat and power recovery (CHP) - 320 kWatt power - electricity;
  - 460 kWatt power - heat
- New gas storage tank , 1000 m3 volume
- New mechanical sludge thickener;
- New desulphurisation unit (dry );

Some units/elements must be replaced to work properly in upgraded system as follows:

- Replacement of sludge scraper in primary sludge thickener;
- Replacement of a gas flare for excess of gas in period of maximum production

Also some auxiliary units are to be replaced as grease pumps, sludge pumps, process control.

**PREDICTED GAINS**

As it was stated before , the main aim of the upgrading is to increase an energy recovery from a biomass. The figure 3 shows simulated biogas production (with minimum 70% methane content) in years 2002-2003 compared with simulated biogas production. This "simulated" values reflect possible biogas production from the same amount of sludge as in period being analyzed, but assuming use of designed, upgraded system.

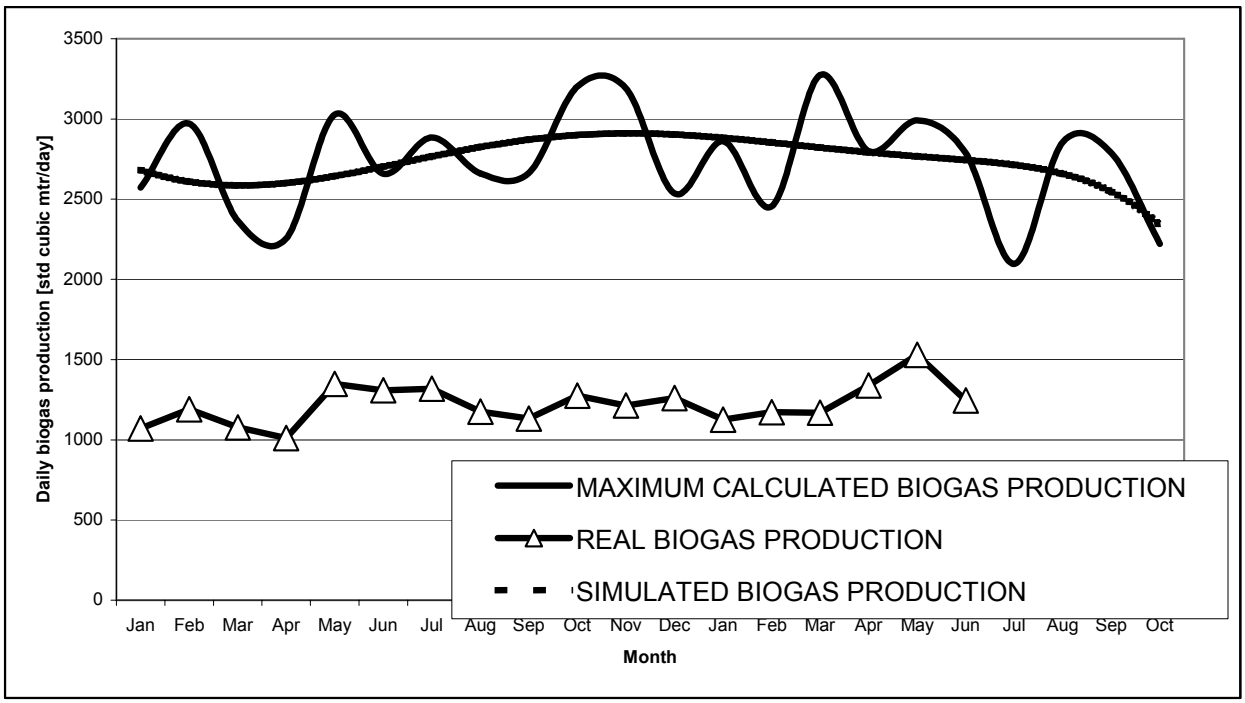


**Figure 3.** Real and possible calculated biogas production.

Besides some other positive effects of the implementation of tests in real terms, as following:

- Improvements of dewatering characteristics of digested sludge resulting in decrease of amount of sludge for final handling (volume and "wet mass" );
- Lower organic content of processed sludge, better ecological characteristics (less odour problems);
- Better utilization of grease trapped in a wastewater train.

## CONCLUSIONS

This paper proves that consecutive development of laboratory studies, procedures than design calculations resulted in design of upgrading of existing WWTP.

Application of methanogenic activity tests may be a valuable tool for a digestion chamber dimensioning in case when the content of sludge is unknown; this is especially valuable in case of changing of general concept of sludge processing.

Proposed design procedures led to exact calculation of a digestion time which is considered the main parameter for the dimesnioning of the sludge processing line at existing plant i.e. the Nowy Sącz WWTP. The digestion time was found to be 23,5 d .

Prediction of sludge characteristics allowed to dimension not only a digestion units but also other auxiliary units (pumps, storage tanks, flare, desulphurisation unit).

## REFERENCES

Cimochowicz-Rybicka M. (1999) Methanogenic activity as a basis of evaluation of pesticides and Cr(III) inhibition of methane fermentation process. PhD thesis in Polish. Cracow Technical University, Kraków, Poland. (In Polish)

Cimochowicz-Rybicka M (2001) Assessment of a biogas production for various feed system at the Nowy Sącz WWTP; Report interim of the Institute of Water Supply and Environmental Protection; Cracow University of Technology, Kraków, Poland (In Polish)

Cywiński B., Gdula S.,Kempa E., Kurbiel J., Płoszański H. (1983) Wastewater treatment (in Polish), v.2 ed. Arkady, Warszawa(In Polish)

Hopkowicz M. Energy Management at WWTP with biogas utilisation; Proc. Of a Polish- Swedish Seminar, Joint Polish Swedish Reports, Report No 7, Stockholm

Kurbiel J., Hultman B., Hopkowicz M. (eds.) (2000) Wastewater sludge and solid waste management – a compendium ; Porc. Of Royal University of Technology – author's draft version, Stockholm, Sweden.

Rybicki S.M., Kurbiel J (2000) Energy saving by retrofitting WWTP from aerobic stabilisation of wasted activated sludge to anaerobic digestion – case study; Proc. Of a Polish- Swedish Seminar, Joint Polish Swedish Reports , Report No 7, Stockholm.

Cimochowicz-Rybicka M., Rybicki S.M. (2003) Selected aspect of risk minimization of sewage sludge disposal Proc. Of a Polish- Swedish Seminar, Joint Polish Swedish Reports , Report No 10, Stockholm