



Memorandum

*To: Mark Hilty, City of Franklin Assistant City Administrator for Public Works
Michelle Hatcher, City of Franklin Interim Water Management Director*

From: Robert Huguenard, PE

Date: June 28, 2017

*Subject: City of Franklin WRF
Preliminary Input on Lystek Evaluation*

Bid documents for an expansion to the Franklin Wastewater Reclamation Facility (WRF) were completed in 2016 after a lengthy design process. The documents included an expansion of the liquids treatment process and construction of a completely new biosolids management system incorporating thermal hydrolysis pretreatment (THP) followed by anaerobic digestion. The THP system was competitively pre-selected prior to completing the design of the biosolids treatment system to ensure the final plans included the appropriate design elements for the biosolids treatment train. On February 24, 2015, the Board of Mayor and Aldermen approved Resolution 2015-04, approving the Letter of Intent with Cambi, Inc. (COF Contract 2015-0032) to provide the THP system. As a result of this bid process and approval, the biosolids treatment system was subsequently designed around the Cambi THP pretreatment process with the appropriate process systems, piping and appurtenances to support the pretreatment step.

Late in 2016, the City was approached by the Chestnut Bend Homeowners Association (CBHOA) with a request to consider an alternative biosolids treatment process by the manufacturer Lystek International Incorporated (Lystek). The proposed Lystek treatment process was presented at a public meeting in October 2016 and the Board of Mayor and Alderman (BOMA) agreed to consider the Lystek process as an alternative to the preselected Cambi process for a pretreatment step for anaerobic digestion. The current system is designed around a thermal hydrolysis process that is used as pretreatment step prior to anaerobic digestion (therefore, the name Thermal Hydrolysis Pretreatment, or THP). The Lystek system is a significantly different process than the currently selected THP process and is intended to be the end process in the biosolids treatment system rather than a pretreatment step. Since the Lystek system is not a true THP process, a more generic definition for thermal hydrolysis will be used when comparing the two systems. It is the intention and preference of the City staff to continue to utilize anaerobic digestion after the thermal hydrolysis process for further volatile solids reduction and the production of biogas for the use in a combined heat and power system for electricity and heat production.

One of the largest differences between the two systems is that the finished product of the standard Lystek system is a liquid fertilizer product rather than a dried solid. In addition, the standard Lystek

system may not meet Class A EQ requirements. Lystek has recently indicated they can produce a product that may meet Class A EQ requirements by raising the pH to 12 through chemical addition, thereby meeting the requirements via alternative 6 of the vector attraction reduction requirements outlined in EPA's Part 503 Biosolids Rule. Lystek has also indicated they can produce an approximately 30% dewatered biosolid using mechanical dewatering, while the Cambi centered system would produce approximately a 35 to 40% dewatered biosolid. Note that during CDM Smith's initial evaluation of biosolids treatment technologies during the Integrated Water Resources Plan (IWRP) development in 2011, alkaline stabilization processes similar to the Lystek proposal were discussed and eliminated from consideration as they did not meet all of the objectives of the IWRP. The Lystek system was not considered at the time of the IWRP biosolids evaluation due to the relative newness of the technology and Lystek's lack of experience in the industry.

At the October 2016 board meeting, BOMA decided to evaluate the Lystek process and the City's Water Management Department (WMD) and CDM Smith began development of a solicitation package for Lystek. The package would provide a submission comparable to the package responded to by the THP system providers during the 2015 preselection package. Since the Cambi system was competitively selected through this rigorous procurement and comparison process, it was decided to define and evaluate the Lystek process with a similar submission process with the same level of rigor.

The purpose of this memorandum is to seek guidance from the Board on the appropriate path forward. Research and work performed on the bid solicitation package by CDM Smith and the City's WMD staff has yielded some important insights into the technical, economic, and practical differences in the implementation of the Lystek and Cambi processes. As such, staff wishes to seek guidance from the Board prior to moving forward with further evaluation of the Lystek system. These considerations and initial analyses are presented below under the following headings:

- 1) Preliminary non-economic comparison,
- 2) Legal considerations with respect to completed pre-selection bid process,
- 3) Delays to the WRF expansion,
- 4) Increase in the cost of the WRF expansion with time,
- 5) Disruption of the SRF loan process and associated implications,
- 6) Added consulting cost to date, and
- 7) Additional consulting cost to change direction and redesign.

A high level comparison of capital costs is also presented comparing the two technologies.

Preliminary Non-Economic Comparison

During selection of the THP system supplier for the current design, an economic and non-economic comparison of the system options was performed. CDM Smith adapted the table that was used in the original selection process to perform the Lystek versus Cambi non-economic comparison. Since the

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 3

Lystek system is significantly different than the systems that were previously compared, the table had to be revised to eliminate criteria that do not apply and add criteria that does apply to the Lystek versus Cambi evaluation. The resulting non-economic comparison is presented in Table A1 and explained in Appendix A. A summary is provided below.

The Cambi System scores much better than Lystek on a non-economic basis with a score of 29 versus a Lystek score of 63. The scoring is on a scale of 25 to 100 with a lower score being more favorable. The comparison criterion and a summary of the evaluation results for each criterion is provided in the following bullets:

- Level of experience – Cambi is more favorable with regard to this criterion as they provide a longer history and experience. Cambi has been manufacturing systems for 22 years as compared to 9 years for Lystek. Cambi has a total of 50/1 (worldwide/US) operating installations versus 7/1 for Lystek. Cambi was given a raw score of 1 and a weighted score of 5 versus 4 and 20 for Lystek, respectively.
- Ability to provide responsive support after startup – The two suppliers were relatively equal for this category as neither have employees in Tennessee and both companies have a relatively small presence in the United States. Both were given raw scores of 3 and weighted scores of 9.
- Company revenue – Cambi scored better than Lystek in this category because their annual revenues are more than four times Lystek's annual revenues. Raw score of 2 and 4 and weighted scores of 6 and 12 were assigned for Cambi and Lystek, respectively. Although revenue is not the sole financial indicator of company stability, it provides an indication of the relative size and success of a company's product line.
- Ability to produce Class A EQ biosolids – This category is a very important discriminator as a critical goal of the Integrated Water Resource Plan (IWRP) is to implement a biosolids treatment process that can produce Class A EQ biosolids. The Tennessee Department of Environment and Conservation (TDEC) and the United States Environmental Protection Agency (EPA) have both concluded that the Cambi centered system proposed by the City of Franklin is capable of producing Class A EQ biosolids. On the other hand, the regulators did not feel that the originally proposed Lystek system was capable of producing Class A EQ biosolids because it does not properly address the vector attraction requirements of the rules.

Since the initial evaluation by the agencies, Lystek has proposed a modification to their system that would involve increasing the chemical addition to bring the pH of the system up to 12. Based on feedback from Lystek, this will enable them to meet the Class A EQ requirements under alternative 6 of the vector attraction reduction, which is applicable to lime treated biosolids. Since both regulators have formally agreed that the Cambi centered system will meet the Class A EQ requirements; and there is a lower level of certainty in regards to the Lystek centered system, Cambi received a raw score of 1 and Lystek received a raw score of 2. This results in weighted scores of 5 and 10, respectively.

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 4

- Diversity of available disposal and reuse options – Cambi also scored better in this category. The Lystek product will have more disposal restrictions due to the high pH (12) of the solids. One of the problems faced with the sludge that is currently produced at the Franklin WRF is that there is only one potential disposal option, which puts the City in a precarious position. Disposal availability was determined as part of the IWRP to be a critical success objective of a new biosolids process. Raw scores of 1 and 3 and weighted scores of 5 and 15 were assigned for Cambi and Lystek, respectively.

Legal Considerations with Respect to Completed Pre-Selection Bid Process

The supplier of the preselected thermal hydrolysis process for the previously designed biosolids treatment system, Cambi, was competitively selected through bidding and a rigorous life-cycle cost and non-cost comparison. Because of the interdependency of the thermal hydrolysis system with the surrounding processes, significant coordination with Cambi was required during CDM Smith's subsequent design of the downstream biosolids treatment system. The agreement with Cambi, however, does not make any guarantees that the designed system will ever be constructed, but there still may be some risk to the City should the decision be made to construct another supplier's system outside of the approved selection. It is recommended that the City's Law Department evaluate this level of risk to the City.

Delays to Wastewater Reclamation Facility Expansion

Now that the SRF funding approvals are in the final stages, CDM Smith anticipates the project could be bid in early August. Continuing to investigate the Lystek process could push the project implementation out by years. CDM Smith estimates that this potential change in direction would push the commencement of WRF construction off to March 2020, which would push completion of the WRF improvements out to March 2023 as detailed below:

- Decision to continue with Lystek evaluation – Assume decision is made in July 2017.
- Complete Lystek Evaluation (3.5 months/November 2017)
- Staff and BOMA approval of Lystek and redesign amendment for CDM Smith (1 month/December 2017)
- Redesign (10 to 12 months/November 2018) - A significant redesign effort will be required as modification to a Lystek centered system would have a rolling impact to the sizing and design of almost every other component of the biosolids treatment system design. For example, the digester sizing would increase, resulting in changes to the design of three different sets of digester pumps, digester gas processing equipment, the combined heat and power system, boiler systems, sizing of the digester building housing this equipment, sizing of HVAC system for the building, sizing of the electrical system, and other components. As a comparison, the design of the current biosolids system required about 18 months after completion of pre-selection of the THP supplier.

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 5

- Permitting processes (3 months/February 2019) – The permitting processes would actually take longer than the 3 months indicated; however, some of the process could occur concurrently with the redesign.
- SRF process (9 months/November 2019)
- Bidding and Award (4 months/March 2020)
- Completion of Construction (3 years/March 2023)

Increase in the Cost of the WRF Expansion with Time

While the construction of the WRF is delayed, the cost of construction will continue to escalate and the cost to the City will continue to increase. Consequently, even if the Lystek system was less expensive, a portion of the savings would be negated by increases in construction costs for the liquid and solids processes due to the later start of the construction of the new system. For example, if construction cost increase three percent per year on average, moving the construction start date out by two years would add about \$6 million dollars to the cost of a \$100-million-dollar project.

Disruption of the SRF Loan Process and Associated Implications

The SRF program has currently committed approximately \$100 million dollars of low interest rate funding to this project. The current SRF interest rate for a 30-year loan is approximately 1.75 percent as compared to an interest rate of 3.25 percent, which is approximately what the City could obtain with other funding sources. A delay in construction would put the SRF funding at risk. Assuming the interest rates cited above and a loan term of 30 years, the City would pay an additional \$28,655,910 for non-SRF funding.

Added Consulting Costs To Date

Following the decision to evaluate the Lystek system against the current Cambi centered biosolids design, the City began incurring consulting costs associated with performing the required evaluation. Associated activities to date include:

- Attendance at the public meeting where Lystek presented their process,
- Meetings with the City staff to establish the scope and direction for this evaluation,
- A December 2016 meeting with Lystek to gain a better understanding of their system and to begin defining the biosolids treatment system components that would have to surround the Lystek process,
- Conceptual design of the overall biosolids treatment system for a Lystek centered system,
- Preparation of a rough draft of the bid solicitation document,
- A May 2017 meeting with Lystek to coordinate after their meeting with TDEC, and
- Preparation of this comparative memorandum.

Currently, the cost for these activities is approximately \$60,000.

Additional Consulting Cost to Change Direction and Redesign

In addition to the above costs, if the decision is made to move forward with continuing the Lystek evaluation, the City would incur additional consulting costs. A summary of the anticipated costs is provided below:

1. Completion of the evaluation and selection process:	\$100,000
2. Permitting	\$50,000
3. Design (Approximately 325 drawings would have to be redesigned and revised)	\$1,100,000
4. TDEC acceptance process	\$50,000
5. SRF process assistance	\$200,000
Total	\$1,500,000

High Level Comparison of Capital Costs

Prior to receiving Board guidance in terms of moving forward, CDM Smith performed a high-level comparison of differences in the biosolids treatment systems that would surround the Cambi and Lystek systems to get an idea of the potential cost savings that might be available by modifying the biosolids process to a Lystek centered system.

Most of the required biosolids treatment system components would be the same for a Cambi centered system and a Lystek centered system. The attached table compares the sizing of the processes for Cambi and Lystek and provides overall thoughts on the potential cost differences. In some cases, it was clear that the process would not change significantly; and therefore, the costs would not likely change. In other cases, it was possible to deduce a rough cost difference based on estimates previously produced for the Cambi centered system and the anticipated difference in the size of the process for the two systems. And in some cases, it was clear the cost would be higher for Cambi or Lystek, but it was impossible to estimate the cost with the currently available information. Overall, this broad analysis indicates that it is unlikely that capital cost savings would be realized by changing to a Lystek based system. In fact, based on the initial investigations, CDM Smith anticipates that the Lystek system may require a larger initial capital cost investment and may also utilize significantly more chemicals, producing significantly less renewable energy and heat to use in the on-site processes.

This comparison assumes anaerobic digestion is included upstream of the Lystek process. Lystek has claimed that their process does not require digestion. If the Lystek process, with additional pH adjustment and without digestion is used to process raw sludge, a list of concerns related to the alkaline treatment of raw sludge applies. These include:

- Potential bacterial regrowth – alkaline treatment alone does not result in volatile solids reduction. Organic matter in the sludge is not removed. Microbial activities are prohibited or

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 7

slowed by the increase in pH. Once the pH conditions change, due to mixing with soil or other changes, bacterial activities may resume.

- Potential odor – odor associated with raw sludge and microbial activities are present as described above.
- Without digestion there will be a higher volume of biosolids to process and dispose. Anaerobic digestion significantly reduces the amount of solids to be processed and disposed of. The addition of alkaline materials to the biosolids also increases the amount of solids to be disposed.

Table A-2
High Level Comparison of Capital Cost

Cost Item	Notes	Approximate Cost Difference (Lystek – Cambi) in Millions
WAS Pumping	No difference	\$0
WAS Storage	No difference	\$0
Sludge Screening	No difference	\$0
Pre-Dewatering	The volume of sludge to be dewatered for Lystek will be smaller, but Lystek will be batch dewatering versus 24-hour dewatering for Cambi. The equipment sizing ends up comparable.	\$0
Pre Digestion Thickening	Needed for Lystek, but not for Cambi. Assuming gravity belt thickeners. Three 2-meter belts needed. Assume \$400 K per belt. Assuming building space allotted for Cambi pre dewatering would be adequate.	\$1.2
Cambi THP Skid Versus Lystek Skid	The Cambi skid would be more complicated, but the Lystek components would have to be larger due to the less concentrated sludge being delivered to Lystek (< 5% versus 11%). The Cambi skid was priced at about \$1.6 million.	Lystek Likely Less
FOG Receiving and Storage	No difference	\$0
Anaerobic Digesters	Lystek would have 3 added digesters for the same plant capacity. Cost for 2 digesters and pumps is about \$3.6 M.	\$5.4
Digester Building	Lystek system would have 3 added sets of pumps. The current pumps require about 1,000 square feet of building. Lystek would require about an additional 1,500 SF of building at about \$300 per SF.	\$0.45
Cambi Post Digestion Dewatering versus Lystek Post Hydrolysis Dewatering	The Lystek would produce about 7% more post digested sludge. Lystek dewatering would require additional building space. Assuming same equipment cost and about 2800 square feet of extra space for Lystek (the area needed for Cambi post dewatering) at about \$300 SF = \$840,000	\$0.84
Post Digestion Biosolids Storage	Lystek will generate about 7% more digested sludge so their storage cost would be more, but the cost wouldn't be linear. The cost for Cambi storage is about \$0.39 million. Assuming 5% increase Lystek additional cost would be about \$0.02 million	\$0.02

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 9

Combined heat and power	Lystek would produce about 11% less digester gas than what Cambi would produce. So, the Lystek CHP engine would be smaller, however, the engine won't produce enough heat for the Lystek system, so the Lystek system will require additional boiler capacity. Overall, the cost may be similar.	\$0
Final Sludge Storage	Lystek system will produce more sludge for two reasons: higher post digestion sludge production and additional sludge production due to chemical addition. Potentially ten (10%) percent more sludge.	~10% increase
Chemical Storage for Dewatering	Lystek will have to dewater 7% more digested sludge, but assumed no difference in cost for system.	\$0
Chemical Storage for Odor Control	Lystek will be higher due to increased sludge storage, but assume no cost difference.	\$0
Chemical Storage for Hydrolysis	Cambi has no chemical costs for hydrolysis. Lystek will require a considerable amount of chemicals and storage.	Increase

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 10

APPENDIX A

NON-ECONOMIC COMPARISON OF LYTEK AND CAMBI PROCESSES

Table A1 Non-Cost Scoring of Thermal Hydrolysis Systems

Non-Cost Criterion		Raw Scoring Criteria			Weight	Cambi B-2 System			Lystek ??? System		
		1	3	5		Raw Score	Value/Comment	Weighted Score	Raw Score	Value/Comment	Weighted Score
1	Level of Experience	Extensive Experience	Moderate Experience	Limited Experience	5	1	Cambi has been manufacturing its systems for 22 years. They have 50 operating facilities worldwide, one in US, plus another seven facilities in bid and construction phase.	5	4	Lystek was started in 2000 and the first system was started up in 2008. There are a total of 8 operating facilities (one in the US). Another system is currently under negotiation.	20
2	Ability to Provide Support After Startup	Strong Support Capability	Same Support Capability	Limited Support Capability	3	3	About 120 worldwide employees and 7 employees in the US. None in TN, but 4 of the US employees have THP O&M experience	9	3	30 worldwide employees and seven employees in the US. Five in Fairfield California, two in the northeast.	9
3	Company Revenue	5 times more revenue than competitor	Same Amount of Revenue	5 times less revenue than competitor	3	2	\$36.9 million in revenues in 2013	6	4	\$8.4 million in 2015 and 7.9 million in 2016	12
4	Ability to produce Class A biosolids	Fully Compliant	Partially Compliant	Not Able to Comply	5	1	Based on discussions with TDEC and the EPA during design of the current system the Cambi system followed by anaerobic digestion can comply with Class A EQ requirements.	5	2	Based on input received from TDEC and the EPA, the originally proposed Lystek system cannot comply with Class A EQ requirements. However, the modified process recently suggested by Lystek is likely to meet Class A EQ.	10
5	Diversity of Available Disposal and Reuse Options	No Restrictions and Numerous Options	Some Restrictions and Multiple Options	Restrictions Apply and One Option	4	1	The sludge produced by the Cambi system followed by anaerobic digestion and dewatering is not restricted in any way and can be reused by residential, commercial and agricultural users and can be disposed of in multiple ways.	4	3	Disposal options for the biosolids produced by the modified process proposed by Lystek would have much more limited disposal/reuse options due to its high pH.	12
Non-Cost Evaluation Score (out of 100 points)						29			63		
Rank						1			2		



Appendix A

Non-Economic Comparison of Lystek and Cambi Processes

To perform a preliminary non-economic comparison of Lystek and Cambi, this appendix uses an amended version of the non-economic comparison table that was previously utilized in the selection of the thermal hydrolysis supplier (Cambi) in early 2015. Since the Lystek system is significantly different than the systems that were previously compared, the table had to be revised to eliminate criteria that do not apply and add criteria that are important to consider in comparing these two options. The table utilizes five non-economic criteria. Each non-economic criterion was given a raw score on a scale of 1 (most desirable) to 5 (least desirable) and weighted on a scale of 1 (low priority) to 5 (high priority). The raw score for each criterion was multiplied by its respective weighting, and the five weighted scores were added together to obtain the Raw Non-Economic Score on a scale of 25 to 100 points. In general, a low score indicated that the system is a more favorable choice.

Note that the originally proposed Lystek system produces a final liquid biosolid that the regulators felt could not meet Class A EQ requirements because it does not address vector attraction requirements. Lystek has since proposed a modification to their system that would include increased chemical addition to bring the pH up to 12 followed by dewatering. The revised process essentially produces an alkaline stabilized sludge. For this evaluation, we have assumed use of this modified version of the Lystek system.

The non-economic criteria and their definitions and weights are described below.

- **Level of Experience.** This criterion captures the overall experience of the system suppliers. It considers the number of years the proposed system has been manufactured and the number of worldwide and U.S., fully operational systems installed. The more installations a system has, the better the track record. More installations illustrate demand and satisfaction for a system, and similar to the number of years the system has been manufactured, it also implies that the system has had its “bugs” worked out in full scale applications. This criterion received a high weighting of 5, because it is critical that the system operate properly with only infrequent shutdowns for maintenance. The longer a system has been manufactured and the more full-scale installations, the lower the score the supplier received.
- **Relative ability to provide responsive support after startup.** This criterion addresses the strength of the supplier and its ability to support the installed system. A lower score is provided to the supplier who has a larger number of employees available to provide service. This criterion received a medium weighting of 3, illustrating the balance between the City’s desire to have on-site support and the expectation that the most appropriate form of support for Franklin would be through remote monitoring.

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 12

- **Company Revenue.** Company revenue is an attempt to quantify the financial stability of the company. Because it is not in the scope of this pre-selection to conduct a complete analysis of the financial stability of the two system suppliers, annual revenues were used as a rough gauge of the size and stability of the company. This criterion received a medium weighting of 3 and reflects the importance of the strength and longevity of the company, as it is in the City's best interest for the supplier to be present in the future to provide support for the system for decades to come. The supplier who earned higher annual revenues received a lower score.
- **Ability to produce Class A EQ biosolids.** This criterion is critical because it measures the ability of the processes to meet the goals of the Integrated Water Resources Plan (IWRP) that was developed by the City with a panel of stakeholders. Therefore, this criterion was given a weighting of 5. A process that is recognized by the regulators as capable of producing Class A EQ biosolids would receive a raw score of 1 while a process that is judged by the regulators as incapable of producing Class A EQ biosolids would receive a raw score of 5.
- **Diversity of available disposal and reuse options.** One of the concerns with the existing biosolids system at the Franklin WRF is that there is only one option available for disposal of the resulting sludge. If that disposal option became unavailable due to regulatory changes, the landfill decided to no longer accept biosolids, or for any other reason, the City could be in a position of either not being able to get rid of the sludge or paying a premium to dispose of the sludge. Therefore, having multiple options for disposal or reuse of the sludge is very important and this criterion was given a weighting of 4. An option with few or no disposal/reuse restrictions and numerous disposal/reuse options would receive a raw score of 1, while an option with disposal/reuse restrictions and a single potential disposal/reuse option would receive a raw score of 5.

Discussion of Non-Economic Analysis

The Cambi and Lystek system were compared using the evaluation criteria outlined above and were given weighted scores of 29 and 63 respectively. The following paragraphs explain the scoring of the two alternatives for each criterion.

Level of Experience

Cambi has been manufacturing its systems for 22 years as compared to 9 years for Lystek. Cambi has a total of 50/1 operating full-scale systems in the world/U.S., respectively compared to Lystek, which has a total of 7/1 operating full-scale systems in the world/U.S., respectively. Cambi has seven more facilities in bidding and construction while Lystek has one facility that is in contract negotiations. Because of the significant difference in the years of manufacturing systems and the number of systems in operation, Cambi was given a raw score of 1 and Lystek was given a raw score of 4.

Relative Ability to Provide Support After Startup

Neither supplier has any employees in Tennessee and both suppliers have only a modest number of employees in the United States. As such, both suppliers were scored neutrally on this criterion.

Preliminary Input on Lystek Evaluation

June 27, 2017

Page 13

Company Revenue

Cambi annual revenues are more than 4 times Lystek annual revenues, so they were given raw scores of 2 and 4 respectively.

Ability to Produce Class A EQ Biosolids

TDEC and the USEPA both indicated that in their opinion the currently designed Cambi centered system is capable of producing Class A EQ biosolids. On the other hand, the regulators did not feel that the originally proposed Lystek system was capable of producing Class A EQ biosolids. However, Lystek has since proposed a modification to their system that would involve increasing chemical addition to bring the pH of the system up to 12. **They have also indicated that they believe they can provide a dewatered product as well, if desired. CDM Smith believes the addition of appropriate pH adjustment would allow Lystek to meet the Class A EQ requirements under alternative 6 of the vector attraction reduction requirements, which is applicable to lime treated biosolids.** Since both regulators have formally agreed that the Cambi centered system will meet the Class A EQ requirements and there is not as much certainty with regards to the Lystek centered system, Cambi received a score of 1 and Lystek received a score of 2.

Diversity of Available Disposal and Reuse Options

The Lystek product will have more disposal restrictions due to its high pH (12). This limitation is a concern and resulted in a score of 3 for the Lystek system and a 1 for the Cambi system.

The results of the non-economic scoring are presented in **Table A1**.