Annex:
Technical Alternatives for Meeting Municipal Waste Management Targets - Integrated Project for *Residual* Waste Management

The Waste Management Plan aims to design an integrated system of municipal waste (MW) management in the Plzeň Region to cover gathering, sorting, collection, transport, pre-treatment and treatment of all fractions of MW based on economically mutually beneficial links among the waste producers (municipalities), transport companies and waste pre-treatment, recovery or disposal facility operators.

The suggested integrated system of MW management is based on the fact that the stipulated targets of 50% material recovery for MW in 2010 compared to 2000 and the reduction of the amount of landfilled biodegradable MW in the coming years cannot be met solely by source-separation of treatable MW fractions. **Treatment technologies** will have to be implemented, namely for **mixed (residual) municipal waste (MMW)**. This Annex focuses on options for the management of mixed residual municipal waste only – it does not consider the separate collection and sorting of wastes, which is addressed elsewhere in the WMP. All options considered assume the same amount of mixed residual municipal waste for disposal.

Implementation of MW treatment facilities within an integrated system requires the involvement of all significant MW producers (municipalities) in the system, and a joint approach to MW treatment under economically beneficial conditions.

Technically, a system can be designed consisting of many small projects for separation and the following material or energy recovery of the separated fractions. Sales opportunities both for the separated materials designated for further treatment, and for energy (or material) use of the produced refuse-derived fuels (RDF) (option A0) need to be guaranteed as part of the system.

Due to the expected level of RDF production, and above all, the contractual guarantee for sales of the produced fuel, an independent source of RDF use should be considered as part of the system (option A).

To implement a biodegradable MW incinerator to dispose of the prevalent part of the waste is another option. Thus, the targets for the reduction of biodegradable MW landfilling for the whole of Plzeň Region would be met (option B).

Another possibility is to combine the two options and to approach waste issues in Plzeň and its vicinity differently than MW treatment in other parts of the region. This option envisages the use of energy from RDF simultaneously with temporary incineration of MMW from the Plzeň area, following source-separation of recoverable materials and hazardous fractions by the public. The waste treatment centres (RDF production) will be first implemented on the local level in the region and the MMW treatment technology will later be finished for the Plzeň area (option C).

The mixture of MMW and high calorific value RDF meets the legal requirements for energy recovery of waste (S. 23 of the Act on Waste no. 185/2001 Coll.).

The possible technical solutions for municipal waste treatment are further discussed in three (four) options:

Option A0: Mechanical Biological Pre-treatment (MBT)
Option A: Mechanical Biological Pre-treatment (MBT) with a Source for RDF Use
Option B: MMW Incinerator
Option C: Combined Use of Recovered Energy (MBT + Direct MMW Incineration)

Option A0: Mechanical Biological Pre-treatment (MBT)

This method of MMW treatment consists of initial mechanical separation (drum separators or ballistic separator) and the following treatment of separated fractions. The light fraction contains primarily a mixture of paper and light plastics of high calorific value and low contents of ashes, and is utilised as RDF.

Another part is the biofraction, which contains high share of organic substances. It is treated using the aerobic process (composting) and utilised e.g. as the substance for landfill technological restoration. The organic substances contained in the resulting substrate are stabilised on the landfill site and they do produce considerably less methane or CO_2, another greenhouse gas, that would result from their incineration.

Depending on the technology used, the landfilled light fraction either remains untreated, or is incinerated in a suitable facility (waste incinerator).

This process could be considered as material recovery of waste first for RDF production and second to substitute soil and construction debris as technological material in landfill restoration. Landfilling of this waste could be eliminated or at least reduced significantly.

The integrated system in place for all considered options provides for bulky waste separation and the separation of fractions with material and energy recovery potential. As bulky waste contains up to 70% of biodegradable MW, it cannot be landfilled unprocessed.

Option A0 introduces a system of gradual implementation of treatment units for MMW and other fractions of separated MW with market defined conditions for sales of the produced fuels (market fuel price). RDF market is only evolving, but it is obvious that fuels from industrial waste will be better valued, as the composition and consequently the quality of the resulting product is known, than fuels from mixed waste where the composition cannot be guaranteed. The RDF price in the EU ranges from 20 to EUR 70 / t and it is paid by the fuel producer to the customer for incinerating this processed waste.

To get a loan or subsidy for a specific project, an investor is obliged to guarantee and provide documentary evidence for the sales of RDF. Therefore, long-term outlet of the product would need to be contracted with a specific operator of a source for RDF use outside of the Plzeň Region. Market conditions for RDF in the next 10 to 15 years are hard to predict. Fuels produced from mixed waste will always require perfect incineration with the corresponding emissions purification. The marketing value can therefore be significantly negative and sales problems may arise as well.

To meet the target of the reduction of biodegradable MW landfilling, it might be permissible to ensure the processing of the organic fraction by composting, and to landfill RDF temporarily in case of marketing problems. Landfilling of RDF violates however the waste management hierarchy (see paragraphs 11 and 23(1)(a) of the Waste Act). Furthermore, it is not clear whether the regional target for landfilling of BRKO can be achieved if the RDF is landfilled (this is only possible under a number of optimistic assumptions).

The biggest risk of this option is that the suggested waste treatment centres may never be implemented unless they become part of an integrated project (one investment covering MMW treatment facilities as well). The implementation costs for one centre to treat approximately 30,000 tons of waste represent CZK 80 to 120 million. A subsidy from one of the EU funds may be considered. However, subsidies cannot be expected to be granted for all the region's centres as independent investments. A possible solution is to contractually guarantee outlet of the produced fuel with a source for RDF use outside the Plzeň Region, while the treatment centres would become part of the investment into the new source or into the pre-treatment of fuel (prior to energy recovery).

Option A: Mechanical Biological Pre-treatment (MBT) with a Source for RDF use

Technologically as well as organisationally, this option is identical with the previous option A0. Implementation of energy recovery technology is considered for RDF produced in the treatment centres, (incineration facilities with corresponding emissions purification, heat recovery and electricity generation). If the facility was implemented on the premises of Plzeňská teplárenská, a.s. the corresponding part of brown coal would be replaced by recovered energy.

Treatment centres and the source for RDF use would be implemented as a single investment covering several independent constructions within an integrated project. The scope of investment (approx. CZK 2 billion including 3 treatment centres) would enable disbursing funds from the EU Cohesion Fund for the investment implementation. This way, the costs of MMW treatment would become roughly equal to those of alternative means of disposal (landfilling).

The disadvantage is that the cost-effective capacity of the facility amounts to approximately 80,000 t fuel per year, whereas roughly 35,000 t will be available in the Plzeň Region in 2013, together with an estimated 20,000 t of bulky waste suitable for incineration (after pre-treatment). The remaining capacity could be used commercially or to produce more RDF beyond the requirements of the EU Directives to reduce the landfilling of biodegradable MW. In that case, it will be difficult to get full funding from the EU funds.

Option B: Municipal Waste Incinerator

This option envisages the construction of a facility to use the energy potential of MMW from the Plzeň area due to the highest concentration of waste and the potential for the use of the heat produced. Approximately 2/3 of the overall amount of MMW produced in the region is expected to be treated here, with regard to its composition and transport distances. As for all the options considered, targets for source-separation by the public remain the same as for the previous option.

The minimum expected capacity of the incinerator is 100,000 t/year. The production of MMW in the Plzeň area represents approximately 50 - 60,000 t/year. The remaining capacity of the incinerator should be filled primarily from the production of the region's bigger towns with favourable waste composition from the point of view of its energy potential (long distance waste transport). It is further estimated that about 20,000 tonnes of bulky waste could be suitable for incineration following pre-treatment.

Technologically and organisationally, this option is the easiest. It has many opponents for various reasons, however. The main opponents' concern is the incineration of waste materials with other (material recovery) potential but after the public's initial separation, this potential in MMW is very limited. Another problem area are the side products (slag and flue ash from emissions purification), which, however, are a product of any incineration. The emissions themselves are a further factor, although, provided the European standards for emission purification are met, they remain very low even compared to other commonly used fuels.

To meet the Waste Management Plan targets, lower capacity than the considered 100,000 t/year would be sufficient for the incinerator. The remaining part of its capacity could be used e.g. for the incineration of sludge from waste water treatment plants.

Option C: Combined Use of Recovered Energy

This option envisages energy use of RDF in combination with incineration of MMW from Plzeň (after its previous source-separation, as in all options). The amount designated for direct incineration of MMW is about 55,000 t, together with a further 20,000 t of bulky waste.

Implementation of one separator with a capacity of 20,000 t located at a natural waste treatment centre in the region's rural areas (a current large landfill) is needed in order to comply with the BRKO reduction target.

To implement this option, a new source for recovered energy use of the minimum capacity of 80-100,000 t/year would have to be built. This system enables to fulfil its capacity and thus to ensure the source's cost-effective operation and the long-term stabilisation of waste treatment price in the Plzeň Region for at least 15 years.

This option can also be understood as a temporary state prior to the implementation of option A, with the MMW from Pilsen to be replaced over time by RDF. This could be driven by the fact that, if sufficient RDF or other wastes were available to fill the capacity of the incinerator, such an option (A) is cheaper for the residents of Pilsen than option C.

Individual Options for Mixed Waste Management Compared:

The basic advantages and disadvantages of the considered options have been described above. The need to stabilise residual mixed wastes before landfilling results is a consequence of the legal requirement to reduce landfilling of BRKO. In order to make a proper comparison of the options, they must all meet the target to the same extent.

The capacities of individual facilities listed in WMP feature a certain reserve, e.g. more MW can be produced than considered or the share of biodegradable MW in MW in the next 10 years can increase in different ways than has been estimated. (The figures presented above have already been adjusted to ensure meeting the targets, but not their exceedence.)

Options Compared

Option		**EC Landfill Directive - Related Issues** (all values in t/y). 2013 target: 41 250												
								Landfilling of pre-treated waste...						
		Direct thermal pre-treatment	Thermal pre-treatment total	Direct MMW landfilling	Direct bulky waste landfilling	Direct landfiling	M pre-treatment input	B pre-treatment input	…after M pre-treatment	…after B pre-treatment	…after thermal pre-treatment	Total landfill	Total BDMW	Surpassing the target	free thermal (+) or external treatment(-)
0	Solely mechanical biological pre-treatment	0	0	4,965	27,464	32,429	139,000	93,130	41,700	65,330	0		41,261	**0%**	0
A	Mechanical biological pre-treatment + RDF use	20,237	54,547	70,965	7,227	78,192	73,000	36,500	0	21,900	10,909	111,001		**0%**	-45,453
B	Classic incineration	93,237	93,237	70,965	7,227	78,192	0	0	0	0	32,633	110,825	41,225	**0%**	-6,763
C	A + B combined	73,237	82,637	70,965	7,227	78,192	20,000	10,000	0	6,000	27,513		41,225		-17,363

Option		Financial Issues								Transportation Issues			Energy Issues	
		Specific thermal costs	Specific costs MBTherm	Annual system costs	Specific system costs	Relative to lowest costs	Specific landfilling costs		Relative to current 'fee' situation	Overall investment	km	t x km	option	(thermal)	Rel. to best option
0	Solely mechanical biological pre-treatment	0 CZK/t	1,272 CZK/t	219 Mio. CZK	**1,278 CZK/t**	**100%**	1,300 CZK/t		98%	435 Mio. CZK	0	0	0%	0 GJ	0%
A	Mechanical biological treatment + RDF use	1,890 CZK/t	1,666 CZK/t	261 Mio. CZK	**1,525 CZK/t**	**119%**	1,300 CZK/t		117%	1,856 Mio. CZK	214,857	1.880,000	76%	17,993 GJ	73%
B	Classic incineration	2,151 CZK/t	0 CZK/t	302 Mio. CZK	**1,763 CZK/t**	**138%**	1,300 CZK/t		136%	1,530 Mio. CZK	206,845		100%	24,604 GJ	100%
C	A + B combined	1,890 CZK/t	1 812 CZK/t	276 Mio. CZK	**1,612 CZK/t**	**126%**	1,300 CZK/t		124%	1,600 Mio. CZK	107,429	940,000	38%	22,427 GJ	91%

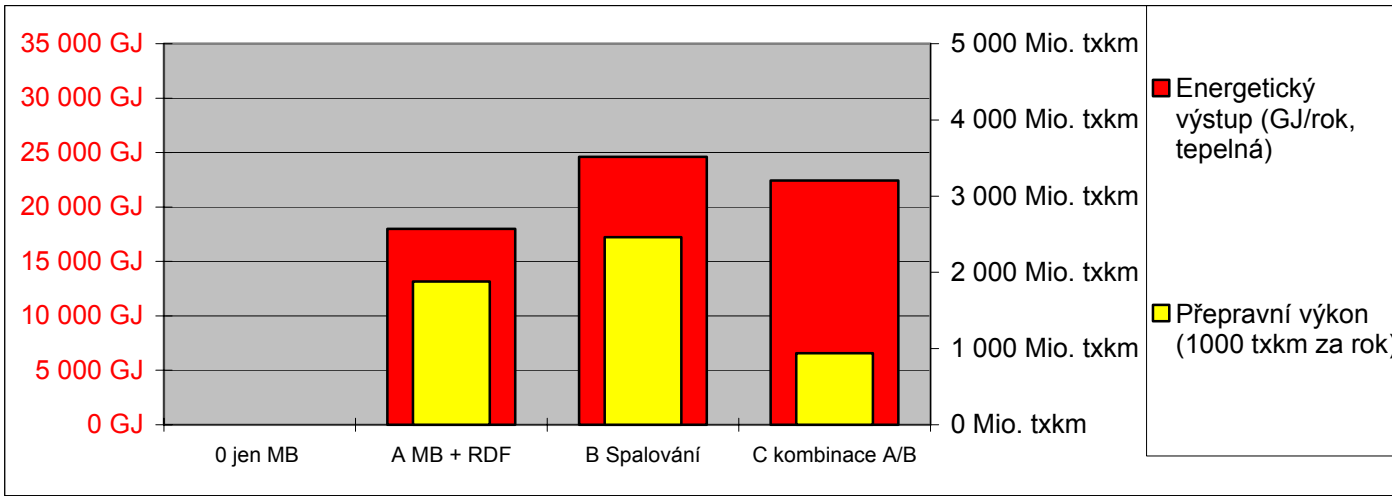
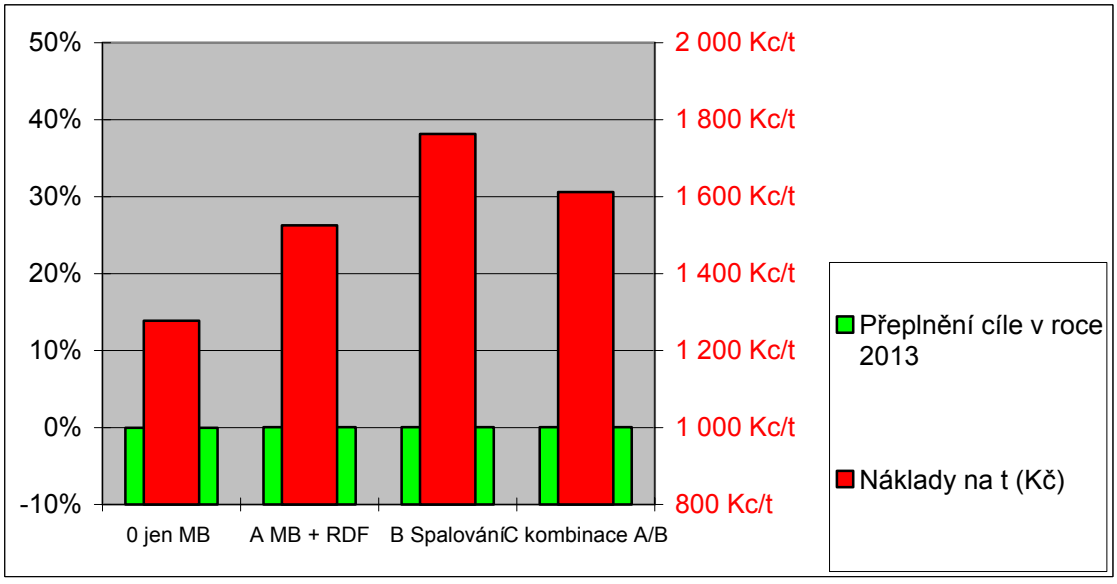


Chart 5: Costs per Ton of Treated MW

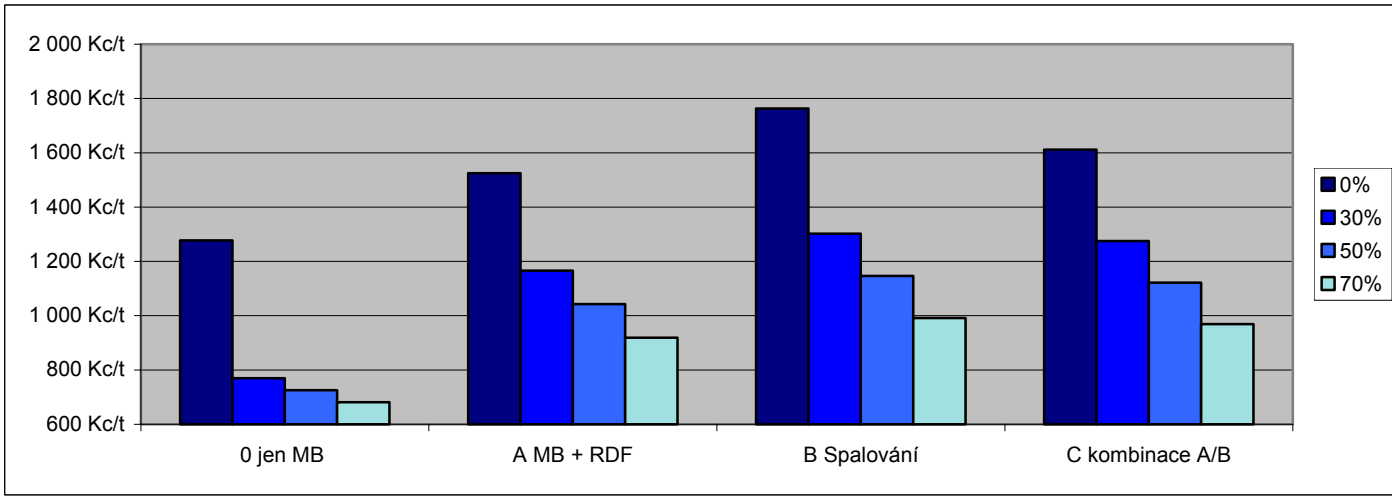


A critical variable determining the cost of the thermal treatment of waste is the value ascribed to heat delivered into the Pilsen district heating system. Following previous studies an upper and a lower boundary were established at 110 CZK/GJ and 58 CZK/GJ respectively. The impact of these two figures is shown in …

Further, the impact of subsidies on the overall funding of individual project types is assessed by option. 30, 50 and 70 % subsidies (EU Cohesion Fund) are considered. The price for the treatment of 1 ton of waste without subsidy is stated for comparison. Chart X shows the level of grant needed to equalise the cost of waste treatment (MBT and/or incineration) with the cost of landfilling, assumed to be 1300 CZK/t (800 CZK/t plus fee of 500 CZK/t).

The level of impact of subsidy on price:				
	0%	30%	50%	70%
0 solely MB	1,278 CZK/t	770 CZK/t	726 CZK/t	681 CZK/t
A MB + RDF	1,525 CZK/t	1,166 CZK/t	1,043 CZK/t	919 CZK/t
B Incineration	1,763 CZK/t	1,302 CZK/t	1,147 CZK/t	991 CZK/t
C A/B combined	1,612 CZK/t	1,275 CZK/t	1,122 CZK/t	969 CZK/t

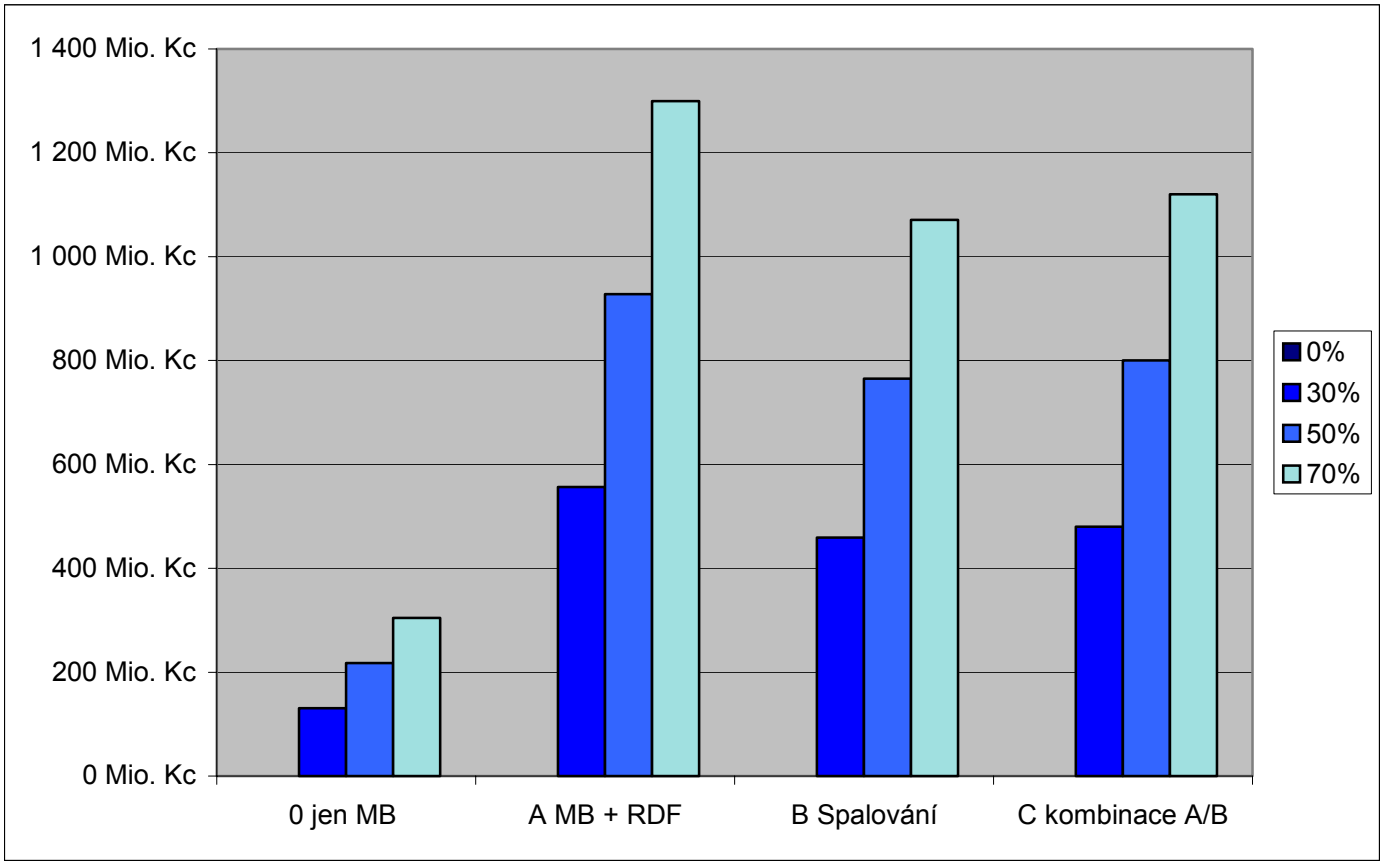
Chart 6: Impact of EU Subsidies on Price



Requirements for EU funding:

Funding Requirements:				
	0%	**30%**	**50%**	**70%**
0 solely MB	0 Mio. CZK	130 Mio. CZK	217 Mio. CZK	304 Mio. CZK
A MB + RDF	0 Mio. CZK	557 Mio. CZK	928 Mio. CZK	1,299 Mio. CZK
B incineration	0 Mio. CZK	459 Mio. CZK	765 Mio. CZK	1,071 Mio. CZK
C A/B combined	0 Mio. CZK	480 Mio. CZK	800 Mio. CZK	1,120 Mio. CZK

Chart 7: EU Funding Share by Option



4. Conclusion

The A0 option is the most cost-effective but there are serious doubts as to whether it complies with legal requirements. In addition, the cost of this option relies upon the assumption that the biologically treated heavy fraction will be exempt from a 500 CZK/t landfill charge. This has not yet been confirmed. In case the heavy fraction is not exempt from this charge, this option is not cost-competitive with landfill without 75% grant support.

The other options all achieve compliance with the basic legal requirement for reduction of landfilled BRKO and comply with the waste hierarchy. If it is accepted that the biologically treated heavy fraction or the RDF fraction are 'materially recovered', then all options except B make a significant contribution to meeting the target for material recovery of MSW. This has not yet been confirmed, however.

The following factors have been identified for a quantitative comparison of the options:

- Cost-effectiveness – the average cost of disposal of one tonne of residual municipal waste in the Pilsen region
- 'Funding effectiveness' – the amount of grant subsidy required to make the cost of MBT and/or incineration the same as the cost of landfill
- Achievement of BRKO target – the certainty with which the given option achieves the target
- Creation of additional employment – the number of additional jobs created

- Energy output – the estimated total energy generated from waste (thermal plus electrical)
- Transport intensity – the product of the estimated number of kilometres and tonnes of waste transported (excluding transport by waste collection vehicles)

The most important of these factors is cost-effectiveness. The following table evaluates the four options by giving a ranking against each of the factors based on the results of a quantitative analysis. All the factors have the same weight, except for cost-effectiveness, which is given the same weight as all the other factors together.

Options Compared - Multiple Criteria

Criterion... …Weight		**A0**	**A**	**B**	**C**
Cost effectiveness	*5*	1	2	4	3
'Funding effectiveness'	*1*	1	3	4	2
Biodegradable MW target	*1*	4	1	1	1
Additional employment	*1*	3	1	4	2
Energy output	*1*	4	3	1	2
Transport performance	*1*	1	3	4	2
	Points total	**19**	**25**	**37**	**26**
	Order total	**1.**	**2.**	**4**	**3.**

Leaving aside option A0, the most cost-effective option is A, followed by C and then B. From the remaining three options, option B is best in energy output but worst in all other criteria (with the exception of the criterion for achievement of the BRKO target, where options A, B and C are indistinguishable). Options A and C are difficult to distinguish, however option A emerges as slightly more favourable overall.

If grant funding is not available, the costs of complying with the legislation represent an increase over the alternative of continued landfilling – in the case of option B (and assuming a low energy value) the cost of incineration would be two-thirds more than the cost of landfilling, representing an increase in total disposal costs of about one-third (when collection costs are also taken into account). If sufficient grant funding is available (e.g. from the EU's Cohesion Fund), then this increase could be negligible.

Original text:

The above analysis shows that apart from the A0 option, which does not envisage the construction of a new source for RDF use, the costs for treatment of 1 ton of waste with the considered subsidy of 50 - 70 % are not significantly different.

In the **A0 option**, only the price of the guaranteed RDF sales can be considered. This price should not be higher than the price of landfill depositing. In the opposite case, the produced fuel would end up landfilled.

The highest risk of this option is that the Region will fail to meet its WMP targets. The risk is caused by the possibility that the planned waste treatment units will not be built or the capacity of the ones built will not be sufficient. The legislative background for the technology

of MMW treatment by mechanical biological pre-treatment has not been created in the Czech Republic so far. That is why all fuels produced from waste remain to be categorised as waste and their incineration falls under the relevant provisions of the Act on Atmosphere no. 86/2002 Coll. on waste incineration. The risk of fuel produced being landfilled in case of marketing problems is high.

Options A, B and C envisage the implementation of a source for the energy use of RDF, or residual MMW, or the combination of the two. From the technological point of view, the specific incineration facilities do not vary significantly. The main difference is in heat capacity and the potential to accept materials with different calorific value. The electricity generation turbine must respect the heat capacity.

The main differences among the options lie in the simultaneous implementation of treatment centres and their economic effectiveness. The centres' environmental as well as economic benefit is the treatment of the biofraction resulting from MBT by means of composting and the consequent replacement of soils or other material used commonly for the technological restoration of landfills. Material used in this manner is exempt from the landfilling fee, which shall amount to CZK 500 per ton in 2009 (under the valid legislation). Moreover, the biofraction's energy value is very low. Pre-treated RDF's energy value is higher than MMW's and they are not quickly biodegradable. Therefore, unlike MMW, they do not need to be treated immediately after it is gathered.

To assess the options, different evaluation systems can be used and individual criteria differently prioritised according to the expected benefit or impact. The following evaluation stemmed from basic multiple criteria analysis:

The analysis shows that the results for options A, B and C are approximately on the same level with regard to the analysis sensitivity. Option A0 turns out to be significantly more beneficial. It however bears the risks described above.

To select the best option for MW treatment and recovery is a very complex task and a sensitive one from the community point of view. From the economic point of view, the price of waste treatment shall not differ significantly due to the expected EU funding disbursement to cover the cost differential of the implementation of treatment technologies meeting the requirements of the EU Directives related to waste management.

From the environmental as well as job creation point of view, the construction of treatment centres at major landfill sites seems to be more beneficial. The source for RDF use would only be used for pre-treated materials, as defined in options A and C. Option B with direct incineration seems the least suitable.

In practice, the selection of an option will depend on the specific form of the business plan to implement the integrated MW management program. In the EIA process, this plan shall be subject to omnifaceted evaluation, including risk assessment.

It is not the aim of the WMP to decide on the specific form of the MW treatment project. The aim of the WMP is to design a MW management system to meet its targets.

The basic measure stipulated by the WMP is a system preventing waste production, a system for separation and recovery of the separated waste fractions, ensuring the take-back of waste and equipment stipulated in the Waste Act, facilitating the implementation of technology to process recoverable waste fractions. Treatment technologies with partial material and energy waste recovery shall be preferred over direct incineration.