Enki public benefit corp. Třeboň
National Radiation Protection Institute
University of South Bohemia, Faculty of Agriculture

Biogas plants as a tool for remediation of contaminated area after radiation accident

Czech- Japan - IAEA workshop

Preview of the expert presentations

19th October 2017, Třeboň

Biogas plants as a tool for remediation of contaminated area after radiation accident
Czech- Japan - IAEA workshop

This workshop was supported by the projectVH20172020015 Disposal of radiation-contaminated biomass after NPP accident: distribution, logistic of harvesting, exploring in bio-gas technology supported by Ministry of the Interior, Czech Republic
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Czech- Japan - IAEA workshop
Biogas plants as a tool for remediation of contaminated area after radiation accident

19th October 2017, Třeboň

Program:

Morning: 9:00	**Venue : Town Hall Třeboň** Lectures 1st Part: 1. Welcome by the Mayor of Třeboň, Mgr. Terezie Jenisová 2. Presentation: Introduction of the R&D Project Safety Research, Ministry of the Interior, Czech Republic, Disposal of radiation-contaminated biomass after NPP accident. Jan Pokorný ENKI 3. Presentation : Fukushima Revitalization after 6 and a half years - on the ground, Shunji Watanabe FP CEC 4. Presentation: Procedures for minimizing waste using Biogas station – basic idea , Jiří Hůlka SURO 5. Presentation: Experiments with Biogas station : Industrial – laboratory scale, Jan Škrkal, SURO 6. Presentation: Sustainable agriculture on contaminated agricultural land Miroslav Kajan, Jan Procházka ENKI
Afternoon: 14:00-16:00	1. Excursion at Biogas station **2.** Bio heating plant, the Aurora spa

Research and Development Project of Safety Research, Ministry of the Interior of Czech Republic, Disposal of radiation-contaminated biomass after NPP accident. Jan Pokorný ENKI

Pokorný, Jan
Enki, o.p.s., Třeboň

Annotation: aims of the project on disposal of radiation – contaminated biomass are briefly introduced and the previous projects dealing with role of vegetation cover in retention of radionuclides are given

R&D Project Safety Research, Ministry of the Interior, Czech Republic

Disposal of radiation-contaminated biomass after NPP accident: distribution, logistic of harvesting, exploring in bio-gas technology.

Likvidace radiačně kontaminované biomasy po havárii JE-distribuce v krajině, logistika sklizně, využití bioplynovou technologií.

- the project is aimed at harvesting of plant biomass contaminated by radionuclides
- its processing in biogas station and treatment of fermentation products
- models of spreading and accumulation of radionuclides in the emergency planning zone of Temelin nuclear power station.

- Use of contaminated biomass for production of electric power and heat,
- safety processing of contaminated digestate (rest after anaerobic digestion of biomass) for its volume reduction.
- Deposition of contaminated concentrated digestate.
- Evaluation and strengthening of retention capacity of landscape to radionuclides.

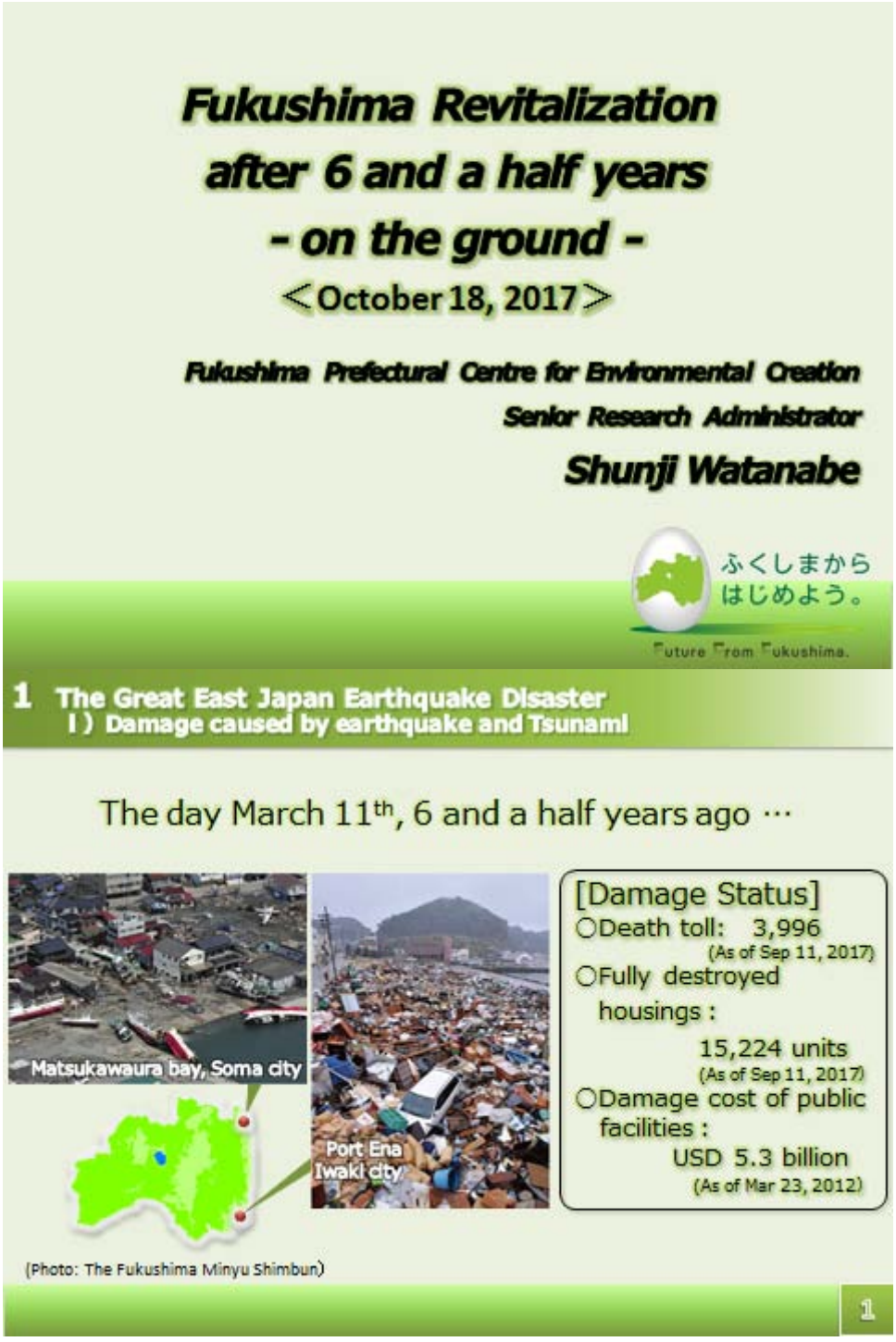
Former R&D projects aimed at disposal of contaminated plant biomas and role of vegetation cover in contaminated areas. Results of these projects are used in the present research activities:

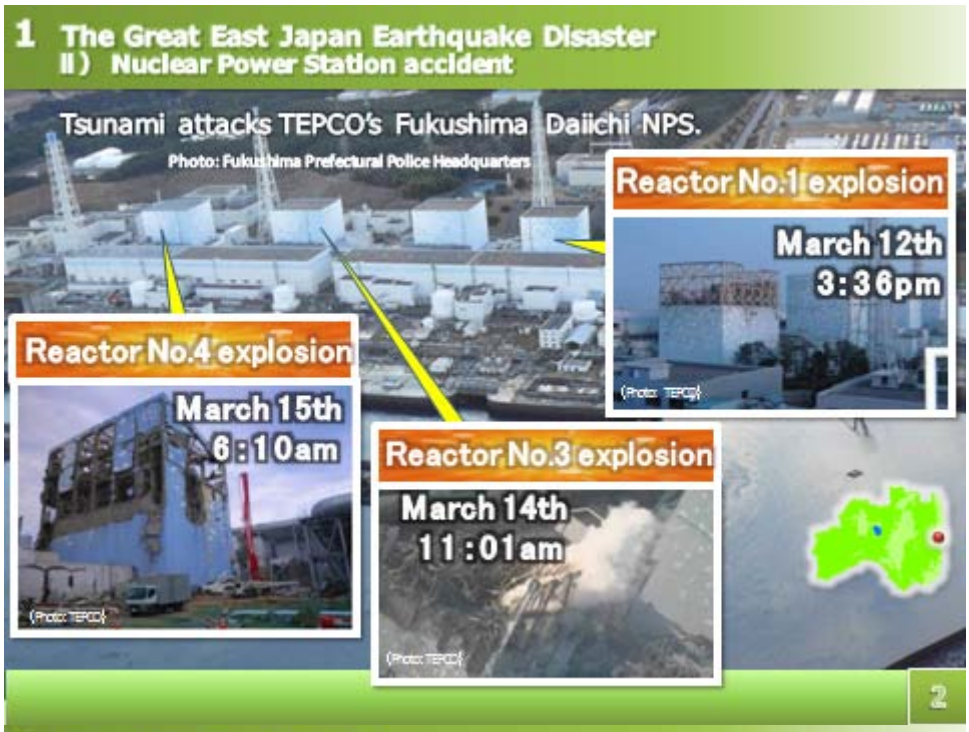
VG – Programme of safety research of Czech Republic 2010 - 2015
Minimizing of impacts of radiative contamination on landscape in zone of nuclear power station Temelín (2012-2015, MV0/VG)
Research of advanced method of detection, estimation and consequent control of radiative contamination (2010 – 2015, MV0, VF).
Methods for evaluation of contaminated territory affected by radiation accident. Role of structure and function of vegetation cover (2008 – 2010, SUJ/JC

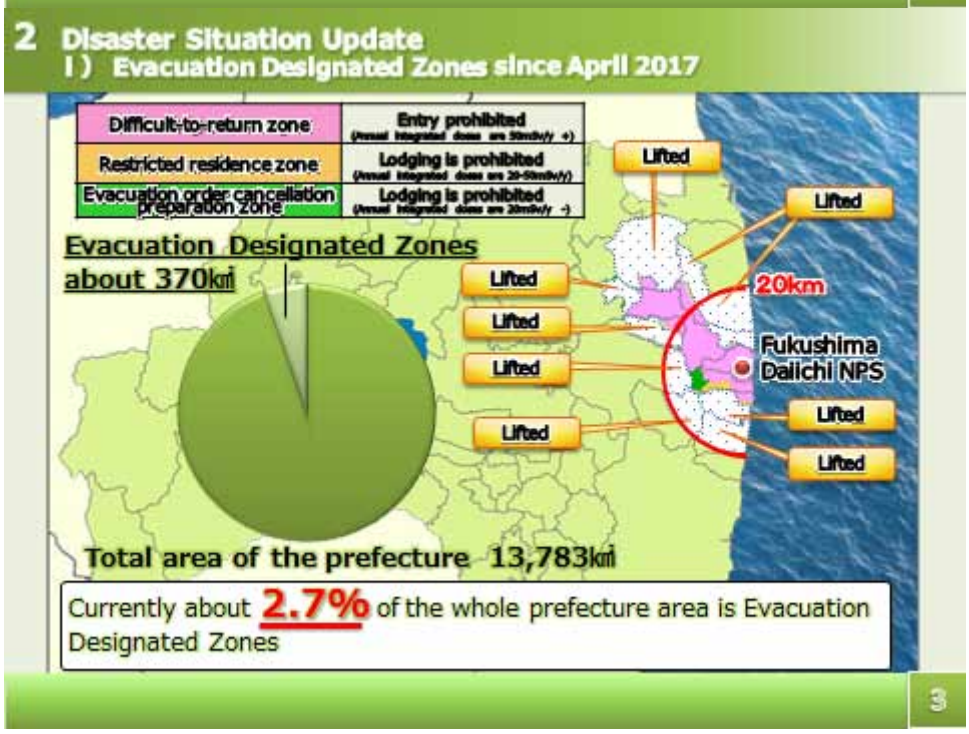
Fukushima Revitalization after 6 and a half years – on the ground

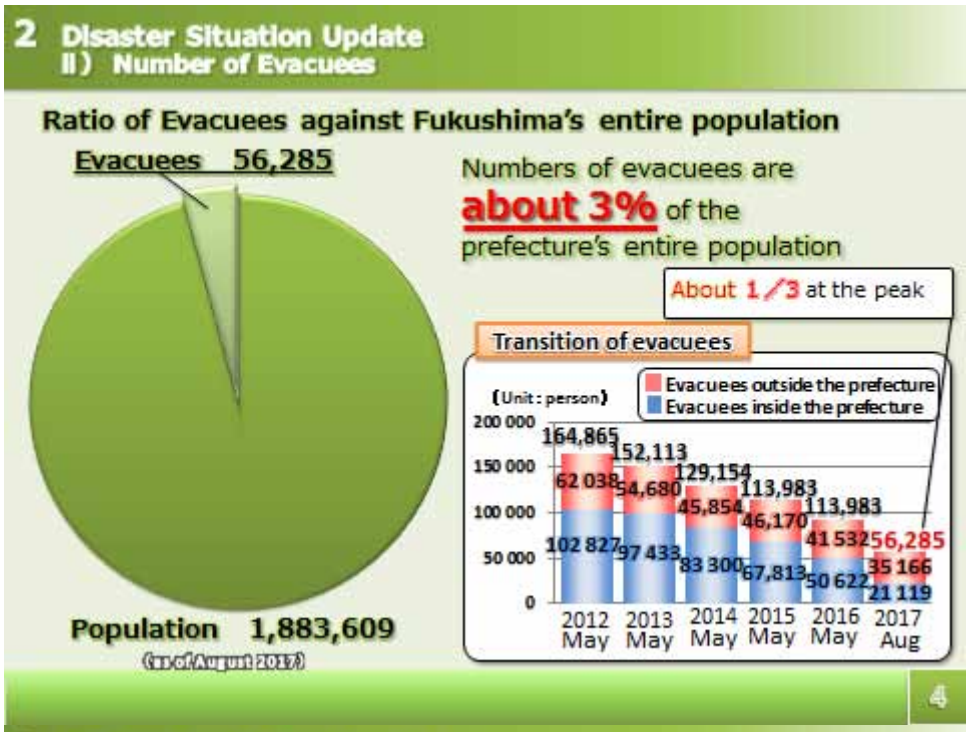
Shunji Watanabe
Fukushima Prefectural Centre for Environmental Creation

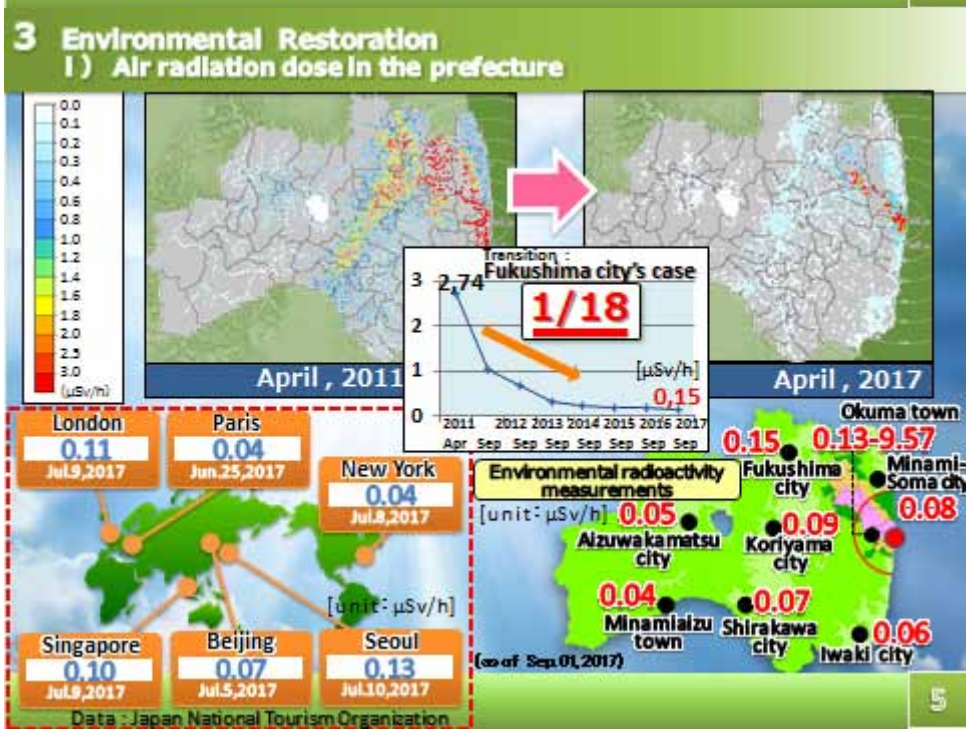
Annotation:




1 The Great East Japan Earthquake Disaster
II) Nuclear Power Station accident
Tsunami attacks TEPCO's Fukushima Daiichi NPS.
Photo: Fukushima Prefectural Police Headquarters
Reactor No.1 explosion
March 12th
3:36pm
Reactor No.4 explosion
March 15th
6:10am
Reactor No.3 explosion
March 14th
11:01am
2


2 Disaster Situation Update
I) Evacuation Designated Zones since April 2017
Difficult-to-return zone
Entry prohibited
Restricted residence zone
Lodging is prohibited
Evacuation order cancellation preparation zone
Lodging is prohibited
Evacuation Designated Zones
about 370㎢
Lifted
Lifted
Lifted
Lifted
Lifted
Lifted
Lifted
20km
Fukushima Daiichi NPS
Total area of the prefecture 13,783㎢
Currently about 2.7% of the whole prefecture area is Evacuation Designated Zones
3


2 Disaster Situation Update
II) Number of Evacuees
Ratio of Evacuees against Fukushima's entire population
Evacuees 56,285
Population 1,883,609
(as of August 2017)
Numbers of evacuees are
about 3% of the
prefecture's entire population
About 1/3 at the peak
Transition of evacuees
(Unit : person)
Evacuees outside the prefecture
Evacuees inside the prefecture
200 000
150 000
100 000
50 000
0
164,865
152,113
129,154
113,983
113,983
56,285
62 038
54,680
45,854
46,170
41 532
35 166
102 827
97 433
83 300
67,813
50 622
21 119
2012 May
2013 May
2014 May
2015 May
2016 May
2017 Aug
4


3 Environmental Restoration
I) Air radiation dose in the prefecture
0.0
0.1
0.2
0.3
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.5
3.0
(μSv/h)
April , 2011
April , 2017
Transition :
Fukushima city's case
1/18
2,74
0,15
[μSv/h]
3
2
1
0
2011 2012 2013 2014 2015 2016 2017
Apr Sep Sep Sep Sep Sep Sep Sep
London
0.11
Jul.9,2017
Paris
0.04
Jun.25,2017
New York
0.04
Jul.8,2017
[unit : μSv/h]
Singapore
0.10
Jul.9,2017
Beijing
0.07
Jul.5,2017
Seoul
0.13
Jul.10,2017
Data : Japan National Tourism Organization
Environmental radioactivity measurements
[unit : μSv/h]
Okuma town
0.15
0.13-9.57
Fukushima city
Minami-Soma city
0.08
0.05
Aizuwakamatsu city
0.09
Koriyama city
0.04
Minamiaizu town
0.07
Shirakawa city
0.06
Iwaki city
(as of Sep.01,2017)
5

3 Environmental Restoration
II) Daily life

Shortly after the accident

Now

Going to school, children wore long-sleeves and masks.

(Photo: The Fukushima Minyu Shimbun)

Current days

In front of JR Koriyama station (Koriyama city)

6

3 Environmental Restoration
II) Current situation of Fukushima Daiichi NPS

Required equipment by areas

Data: TEPCO

Shortly after the accident

Areas working in protecting clothes

Now

Areas working in protecting clothes

Areas working in general work clothes

- Due to the "facing work", radiation dose is reduced, and it is not necessary to wear a full-face mask in most areas of the premises !

"facing work"

Paving the ground with asphalt etc.

Wearing only work clothes (January 2016 Photo: TEPCO)

- Improvement of work environment
  - setting up meal service center and large resting place

7

4 Reconstructing and Development of Social Infrastructure
Recovery from the disaster

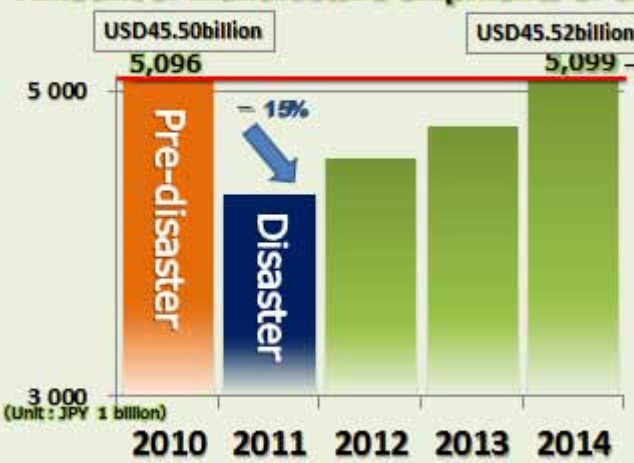
Public works for restoration

Out of all the public works to restore the sites damaged by the disaster, 99% have started and **91%** have been completed.

8

5 Recovering the Regional Economy

Amount of manufacture shipments of the prefecture



More than 100%
recovery compared to pre-disaster levels

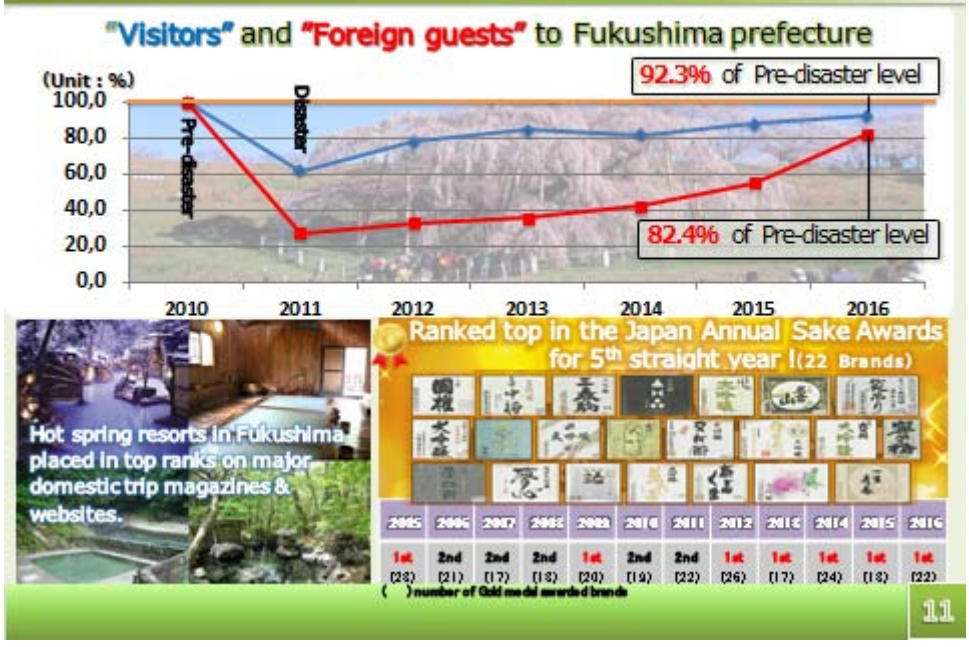
9

6 Unchanged Beautiful Landscape
Ⅰ) Scenery in Fukushima

DIAMOND ROUTE JAPAN Search

10

6 Unchanged Beautiful Landscape
Ⅱ) Tourism Industry Recovery



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7 Food Safety and Security Efforts
I) Tough standard

Japan adopts stricter level of Standard Limits.

(Unit : Bq/kg)

Japan (Standard limits under the Food Sanitation Law)	Codex Alimentarius Commission CODEX STAN 193-1995	EU Council Regulation (Euratom) 2016/52	USA CPG Sec.560.750 Radionuclides in Imported Foods – Level of Concern
Generalfood...100	Generalfood...1,000	Generalfood...1,250	All food...1,200
Milk...50		Milk...1,000	
Infant food...50	Infant food...1,000	Infant food...400	
Drinking water...10		Drinking water...1,000	

※It is not possible to simply compare the numerical values because the reference levels were established by taking into account the estimated impact of the amount of food ingested, the proportion of food containing radioactive substances.
※The Codex Alimentarius Commission, EU and Japan have designated the upper limit of additional doses as being 1 mSv/year.

Data : Consumer Affairs Agency, Government of Japan

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7 Food Safety and Security Efforts
II) Monitoring

"Radioactive substance monitoring" is conducted. Items exceeding the standard limits in inspection before shipment are never distributed.
Although some cases were seen immediately after the accident exceeding the standard limits, at present there is no exceeding cases except for some wild plants and fish.

Results: Testing of every bag of rice

Aug 24, 2016 - Mar 31, 2017

	Number of inspections (case)	exceeding the standard limits (number)	(ratio)
Brown rice	About 10.2 million	0	0.00%

99.99% of rice produced in 2016 is less than the detection limit (25 Bq/kg)

Results: Monitoring

Apr 1, 2017 - Mar 31, 2017

Product	Number of inspections (case)	exceeding the standard limits (number)	(ratio)
Vegetables & Fruits	3,793	0	0.00%
Livestock product	4,349	0	
Cultivated Mushrooms	1,049	0	
Marine Fishery products	8,766	0	
Inner water-cultivated fish	118	0	
Mountain plants & Wild Mushrooms	783	2	0.26%
Inland water Fishery products	621	4	0.64%

The price of prefectural agricultural products has remained at a lower level than before the earthquake disaster, and some countries are continuing import restrictions.

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8 Efforts for Revitalization

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Fukushima Prefectural Centre for Environmental Creation

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Centre for Environmental Creation

Fukushima Prefectural Centre for Environment Creation is established by Fukushima Prefecture as a central organization to conduct research and provide information and education with the aim of recovering and re-creating the environment.

The course of the past

1. The public opening was made in July 2016.
2. Japan atomic energy agency, National institute for environmental studies and Fukushima government joined.
3. IAEA is a supporting Fukushima renovation program. ("IAEA RANET CBC" is designated.)

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Centre for Environmental Creation

Outline of Centre

Fukushima Branch
(Fukushima City)

Environmental Radiation Centre
(Minamisouma City)

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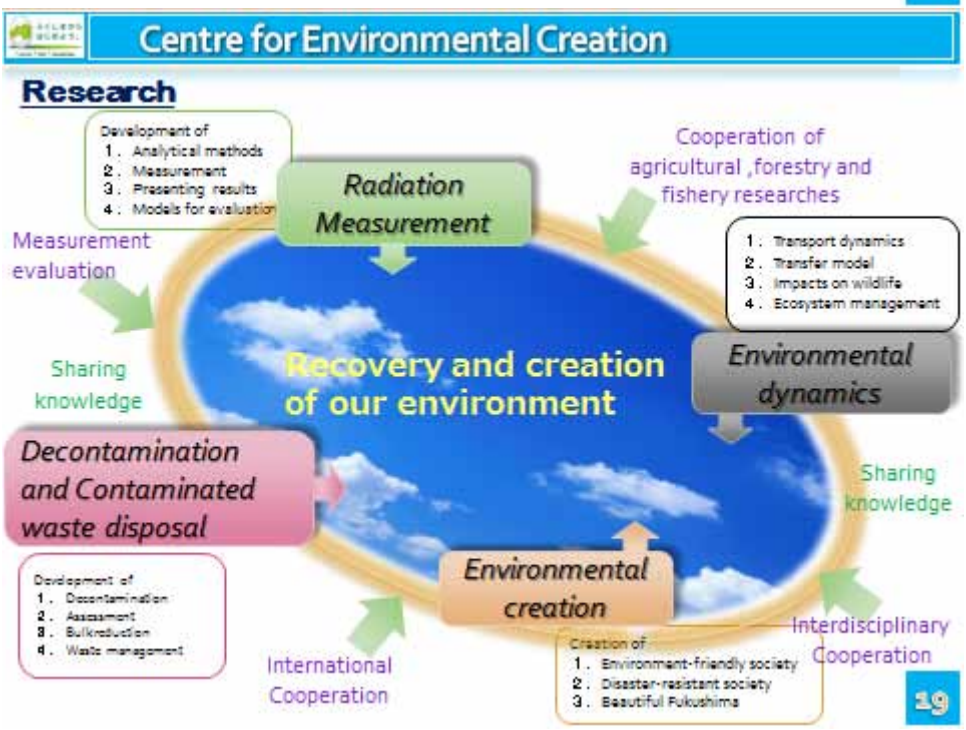
Centre for Environmental Creation
Medium-and Long-Term direction (2015 to 2024)
Monitoring results
Monitoring
Construction and operation of monitoring system
Centralized control of monitoring data
Construction of arrangements for emergency monitoring
Calibration of measuring instruments, etc.
Monitoring results
Measurement methods
Needs
Monitoring results
Needs
Activities in exchange building
Collection and provision of information
Collection and provision of monitoring data
Collection and provision of data on radiation and decontamination
Collection and provision of research outcome
Provision of information on recovery of the environment and rehabilitation of local areas, etc.
Education, training and exchange
Education on radiation, etc.
Training for recovery of the environment and environmental creation
Exchange with people of the Prefecture, NPOs, concerned organizations, etc.
Up-to-date information
Needs
Developed technologies
Needs
Research
measurement of Radiation
Decontamination and contaminated waste disposal
Environmental dynamics
Environmental creation, etc.
Outcome of research
Outcome of research
Human resource development program
18


Centre for Environmental Creation
Research
Development of
1. Analytical methods
2. Measurement
3. Presenting results
4. Models for evaluation
Radiation Measurement
Cooperation of agricultural ,forestry and fishery researches
Measurement evaluation
1. Transport dynamics
2. Transfer model
3. Impacts on wildlife
4. Ecosystem management
Sharing knowledge
Recovery and creation of our environment
Environmental dynamics
Decontamination and Contaminated waste disposal
Sharing knowledge
Development of
1. Decontamination
2. Assessment
3. Bulkreduction
4. Waste management
Environmental creation
International Cooperation
Interdisciplinary Cooperation
Creation of
1. Environment-friendly society
2. Disaster-resistant society
3. Beautiful Fukushima
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Centre for Environmental Creation

Information and Communication Building

■Our Basic Attitude

Our experience-based exhibition is designed to solve worries and questions of people in Fukushima. We expect deeper understanding of radiation and environmental problems in our daily life, and support the intention to recover and further create our environment.

We expect our visitors including our children share the knowledge and intention, obtained during learning and experiences in our centre, with various communities. The centre would be a starting position to imagine and create the future of Fukushima, and dispatch it to the world.

■Information and Communication Building(image)

Fukushima Environmental Creation Town

Radiation Visualization Wall

Environmental Creation Theater

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Fukushima's special products

Okiagari Koboshi "Rising Little Buddhist"

It is a lucky charm of Fukushima wishing for health and family safety. When it falls down it gets right back up again.

Procedures for minimizing waste using Biogas station

Jiří Hůlka, Jan Škrkal, Petr Rulík,
National radiation protection institute (SÚRO, v.v.i.) in collaboration with ENKI Třeboň

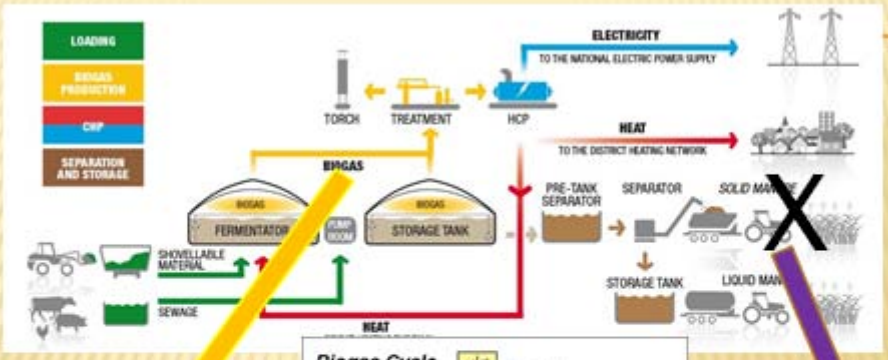
Annotation:

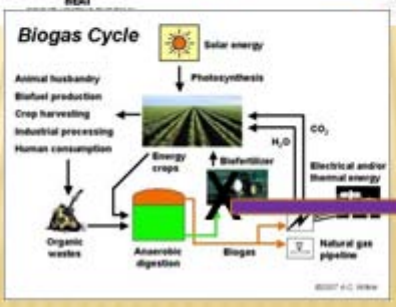
We present the basic idea how to use biogas station for minimizing of large amount of agricultural waste (crop, plants) contaminated by radionuclides after nuclear accident. The advantage of proposed procedure is not only to minimize contaminated waste for disposal, but also recover energy to partially reimburse the costs of waste disposal. Feasibility can be verified in reality due to existing Chernobyl Cs-137 residues in the Czech landscape and thanks to new ultra-low very sensitive measurement based on HpGe gamma spectrometry in deep underground laboratory Modane.

IDEA :
WHY TO USE BIOGAS STATION

1. Minimize large amount of waste (crops, plants, etc) contaminated by radionuclides
2. Obtaine energy (recover energy) to partially reimburse the costs of waste disposal

Verification could be done **in reality** „thanks“ to existing Chernobyl Cs-137 residues in the Czech landscape and thanks to very sensitive measurement methods





IMPORTANT:
Biogas is without Cs137 and could be used

radwaste

PROCEDURE

a. Crop, plants contaminated (bio waste)
b. Silage
c. Fermenter tank
d. Gass is filtered – clean from Cs137 a Sr90
e. Digestate (mud, very humid) – separation necessary
f. Research of methods for separation
g. Dry waste : disposal or incineration (available and tested technology, without Cs 137 escape to atmosphere)

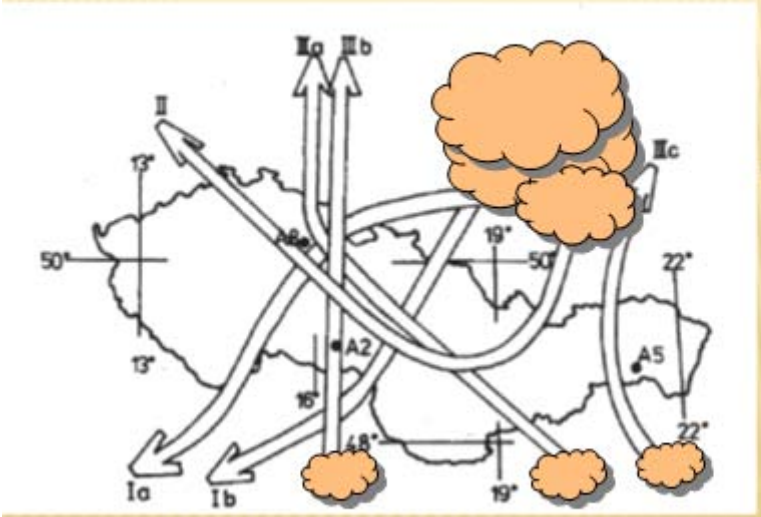
EXPERIMENTAL VERIFICATION OF IDEA

Verification could be done **in reality** „thanks" to existing Chernobyl Cs-137 residues in the Czech landscape and thanks to very sensitive measurement methods

CHERNOBYL CONTAMINATION CZECH REPUBLIC

5

Air contamination – trajectory April-May 1986
(radionuclide concentration : tens and hundreds Bq/m3)



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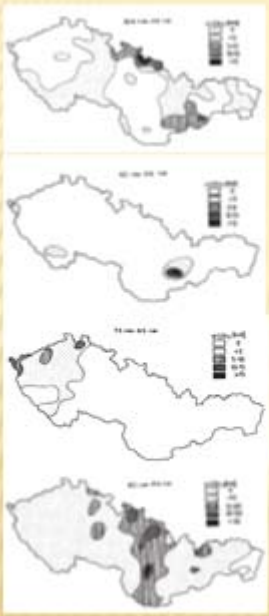
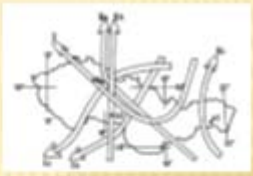
Radionuclides fallout inhomogeneous due to rain (precipitation)

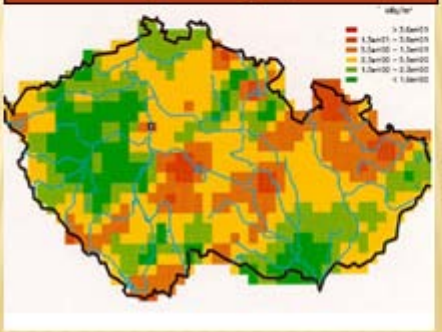




^{137}Cs

$a = 5,7\ kBq/m^2$

(0,1 až 39 kBq/m2)



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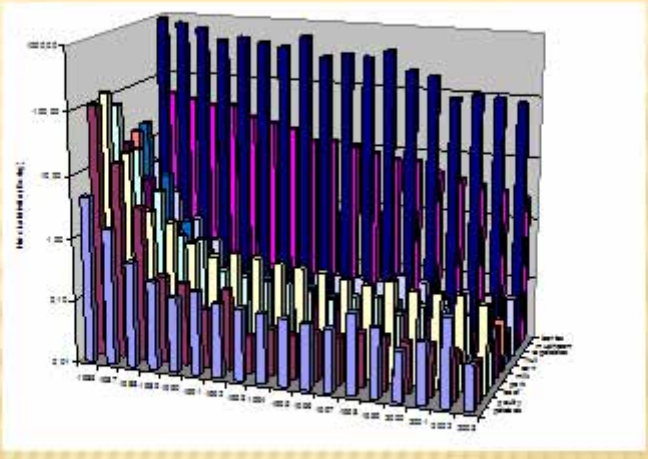
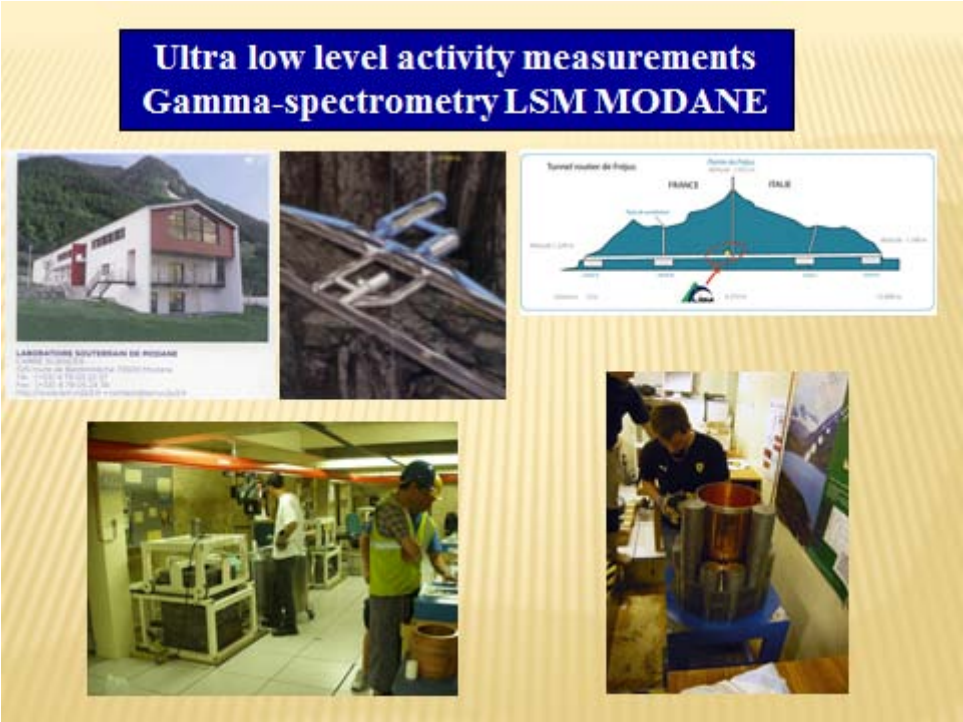
FOOD AND PRODUCTS : CS-137 (FROM 1986)



Today typical Cs137 mass concentration in the crop, plant, grass .... 0,1 -1 Bq/kg

8

Low level activity measurements Gamma-spectrometry SURO


Ultra low level activity measurements
Gamma-spectrometry LSM MODANE
FRANCE
ITALIE

Experiments with Biogas station Industrial – laboratory scale

Jan Škrkal
National radiation protection institute (SÚRO, v.v.i.)

Annotation:

The experimental procedures for sampling and analysis of samples from an industrial biogas station are described in the presentation. Methods of determination of ^{137}Cs in silage, wheat, digestate and filter from biogas station Třeboň are discussed. Preliminary conclusions of the initial measurements of ^{137}Cs by HPGe detectors are outlined and future experiments are indicated. A procedure for the preparation of an uncontaminated test sample of silage and silage sample contaminated by ^{134}Cs for use in an experimental biogas plant is described.

EXPERIMENTS WITH BIOGAS STATION
INDUSTRIAL – LABORATORY SCALE

Jan Škrkal
National radiation protection institute
(SÚRO, v.v.i.)
Tel.:00420 725 338 014
Mail: jan.skrkal@suro.cz

Industrial scale - Biogas station Třebon (BGS Třeboň)

Sampling – monthly

Matrixes inserted in the BGS Třeboň:

corn silage
grass silage
GPS silage (whole plant silage)
wheat

Products:

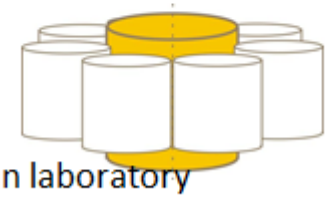
digestate (monthly sampling)
gas (filtr – annual sampling)

Geometries

- Silages – marinelli baker 3 L, natural state
- Digestate – 0.2 L cylindrical vessel (1.2 L)
- Filter – 0.2 L cylindrical vessel

Measurement conditions

- **HPGE** detectors – relative efficiency 140 – 150 %
- **Energy** – 662 keV
- **Laboratory resolution** (MDA) (600 000 s):
  - silages MDA = 0,02 Bq/kg
  - digestate MDA = 0,035 Bq/kg (1,4 L)
  - filter MDA = 0,015 Bq
- **MODAN**
  relative efficienty 140%
  resolution 20 – 50 x better than laboratory



Preliminary results

- The activity of ^{137}Cs in the filter was not detected (test of penetration neaded)
- The activity of Grass silage is higher and contaminate the final product (digestate) -> silage have to be sorted before entering BGS

Planed experiments

- Other Biogas stations – sampling and measurement
- Separation between solid and liquid phase
- The possibilities of liquidation (drying, burning, ..)

Laboratory scale - experimental BPS

- ^{134}Cs
- test uncontaminated samples
- contaminated samples of corn and grass silage
- experimental BGS
- Measurement

Experimental contaminated corn silage

- experimental silage vessel – 8 L, 5.5 kg
- 2 samples (1 sample – 2 vessels)
- contamination – sprayer, between layers
- activity of ^{134}Cs 100 Bq/kg f.w.

Sustainable agriculture on contaminated agricultural land

Kajan Miroslav[1], Procházka Jan[2]
[1] ENKI, o.p.s. Třeboň, [2] Faculty of Agriculture, University of South Bohemia in České Budějovice

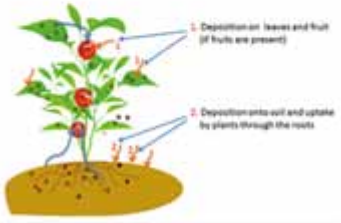
Annotation:

Diverse natural disasters (floods, earthquakes, typhoons, major accidents) may cause restrictions or even stop of agricultural activities in the damaged area leading consequently to various negative effects. The risk of a potential radioactive contamination of the agricultural landscape is a very serious problem, and its solution plays an important role in emergency plans. What to do with contaminated (wet) plants biomass? Anaerobic digestion is the ability to process wet biomass and at the same time to produc energy. Closed energy independent cycle is formed; the commercial product of such cycle is rather energy (electricity, biomethan, heat) than agricultural crops. Alternative use of agricultural products for energy represents a solution for affected region. The advantage of the proposed solution is that the necessary technological elements of the model are established, validated and can be used immediately

Disaster and agriculture

Diverse natural phenomena (earthquakes, typhoons) as well as human activities (nuclear power plant accidents) occurring locally or on a larger area may lead to a temporary degradation of agricultural land.

Although agricultural production is sustainable the products may be unacceptable to the market. Ultimately, it may cause restrictions or even stop of agricultural activities in the damaged area for a long time.

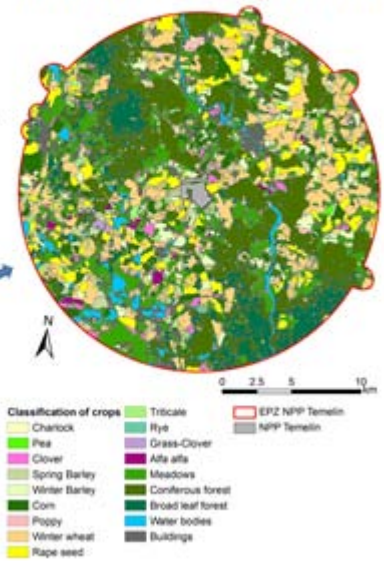


Contaminated soil/products negative effects on farms and agri-business

- direct damages on crops and livestock – **huge amount of unacceptable products**
- decreased income due low (no) market demands for local products
- **ultimately, it may cause restrictions or even stop of agricultural activities in the damaged area leading consequently to various negative effects**
- disruption of farming activities can lead to the next reduction in soil quality
- lost value of farmlands
- increasing unemployment and drop in the life quality

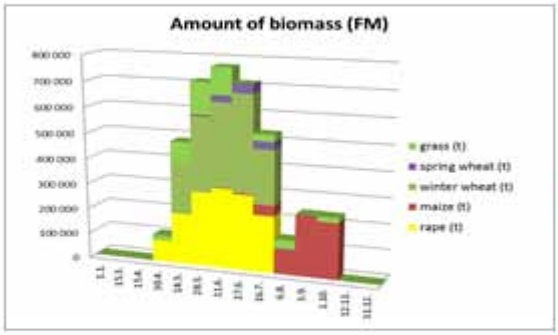
Temelin NPP - installed power 2000 MW
South Bohemia (CZ)

Crops in Emergency Planning Zone (EPZ) of Nuclear Power Plant (NPP) Temelín

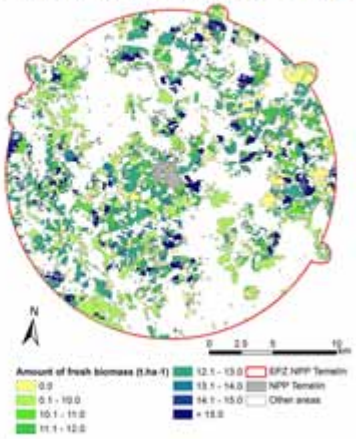


Agricultural (contaminated) plant biomass
in model territories NPP Temelín

Amount of biomass (FM)



Above ground biomass on agricultural fields in Emergency Planning Zone of NPP Temelín



- Cca 20 species of agricultural plants
- Max. of plant biomass May – July
- Different growth stages during year
- Different composition during year (DW 15 – 40%)

What to do
with contaminated (wet) plants biomass ?

Landfill,

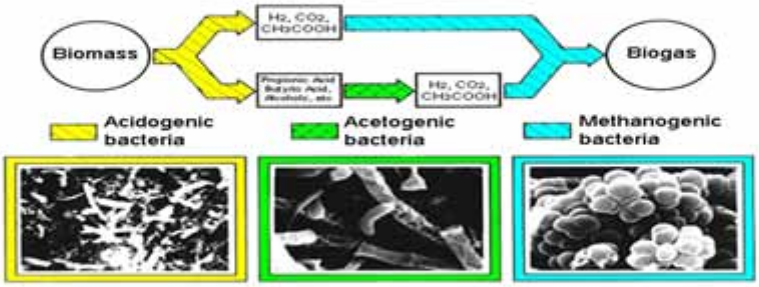
Composting

Incineration

Anaerobic digestion
the ability to process wet biomass + energy production
agricultural production not for food/feed BUT for energy production

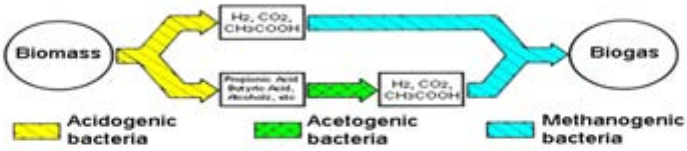
Anaerobic digestion

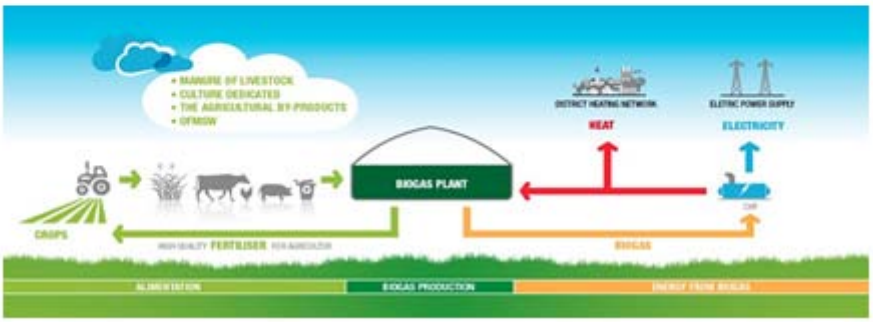
Anaerobic digestion is a collection of processes by which consortium microorganisms break down biodegradable organic matter in the absence of oxygen.



Products of AD :
Biogas mixture of gases (CH4, CO2, etc.)
Sludge (decomposed matter and biomass of microorganisms)

Biogas Plant



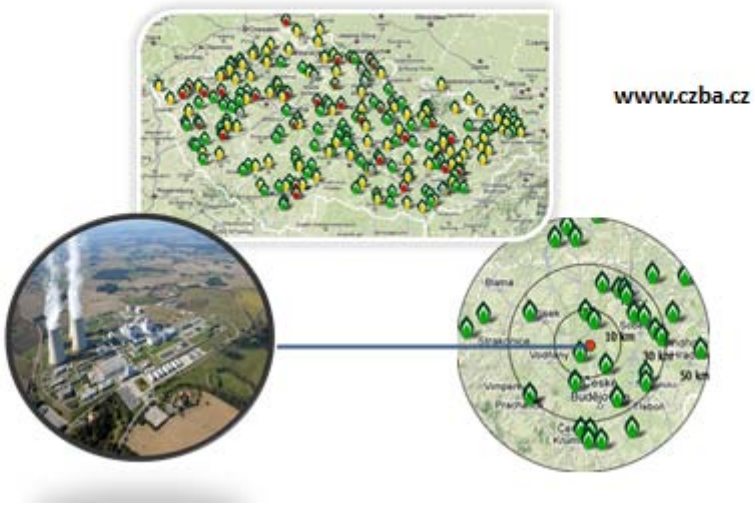


Biogas plants

1 t plant biomass (35% DW)

200 m^3 of biogas = 300 $kWh_{el.}$ +1GJ heat

I. Why we think about biogas plants in the project ?



II. Why we think about biogas plants in the project ?

- huge amount of unacceptable products = contaminated biomass
- **PROCESSING OF THESE BIOMASS**

- decreased income due low (no) market demands for local products
- **INCOME FROM PRODUCED ENERGY**

- ultimately, it may cause restrictions or even stop of agricultural activities in the damaged area leading consequently to various negative effects disruption of farming activities can lead to the next reduction in soil quality
- **AGRICULTURE ACTIVITIES CONTINUE – PRODUCT=ENERGY**

- lost value of farmlands
- **BIOREMEDIATION = IMPROVE**

- increasing unemployment and drop in the life quality
- **FRAMERS ACTIVITIES CONTINUE only PRODUCT IS ENERGY**

Agriculture
for bioremediation and energy production

- Closed energy independent cycle is formed; the commercial product of such cycle is rather energy (electricity, biomethan, heat) than agricultural crops.
- Alternative use of agricultural products for energy represents a solution for affected region.
- The advantage of the proposed solution is that the necessary technological elements of the model are established, validated and can be used immediately.

Thank you
for your attention!

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