

## **Forest Fire Protection by 24h Monitoring, Wood Collection Intended for District Heating Plants and Easy Access Routes Assigned to Firemen and Tourism**

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**ABSTRACT:** The paper describes the technical details of the pilot project, aimed for Dalmatian islands of Brac, Hvar and Vis, which integrates a spectrum of preventive fire protection measures on the one side, and the long-term energy supply based on Solar-Biomass-LPG district heating plant, on the other side. This fire prevention project is a part of fire fighting measures initiated by authorities of Split and Dalmatian County. Our holistic approach to fire fighting is unique in Croatia. It will be based on the information system, which could be used not only for planning fire preventive actions described in this paper, but also in fire management and for post-fire planning of the burned areas recuperation.

**KEYWORDS:** bio-energy management, biomass trade, biomass production, forest-fire prevention

### **1 INTRODUCTION**

In summer seasons the seven coastal counties in Croatia and in particular the Adriatic islands are permanently exposed from a high to a very high fire risks, due to densely-spaced conifer forests. In the year 2003, as many as 130 times occurred the wildfire in Split and Dalmatian County. The total burn down area in the year 2003 was 9.700 ha. The direct and indirect damage of the lost woody biomass in 2003. in Split and Dalmatian County was assessed at the level of 16 and 60 mil.€, respectively.

The total biomass burned down volume in all littoral areas including islands was 220.000 m<sup>3</sup> of which 125.000 m<sup>3</sup> was in Split and Dalmatian County.

The energy equivalent of the 2003. burned down biomass in Split and Dalmatian County is nearly (85%) equal to the value, which were needed to cover the present yearly domestic hot water (DHW) demand for 1,5 million of residents in the coastal counties. Presently, more than 90% of the DHW in the littoral area is being prepared by electrical boilers. If we assume the present price of electricity, the lost of money equivalent were around 50 mil.€.

From all fires in the region, about one half are the result of individual carelessness and other reasons coming from human behavior or man made structures (like 0,4 kW electric transmission lines). The other half is due more or less to pyromaniacs.

The high fire damage costs are due to a lost of biomass, olive oil trees, vineyards and agriculture fields. There are in addition fire-extinguishing costs as well as the costs of environmental sanative measures, which in many cases are very high. Therefore, the basic aim of a fire protection program will be lowering of wildfire risks. Costs of many preventive fire protection measures, which are not established in the field as yet, are mostly quite low in comparison to the total wildfire burn down damage.

### **2 FIRE PREVENTION – THE PRESENT STATE OF THE ART IN DALMATIA**

The fire hazards in Dalmatia are very high during the summer. Also, the damage risks of properties by wildfires are high in the season. The reasons are many and lots of them are mutually dependent. Few of them deserving more attention are:

- The present measures of fire prevention in the practice “fire protection as usual” are very low valued, in too many cases they even do not exist.
- The visual monitoring practice exists only on some small areas, which are quite insignificant to the region as a whole. There are no modern methods of video and thermal monitoring as yet in the whole region. The direct consequence of no systematic monitoring are too long delays of fire alarms, which are additionally not well covered by information when and where the fire occurred. Most fire alarms are coming from residents by their GSM calls. Based on low reliability of such non-professional information, the fireman management has to do a nearly impossible mission. In many cases it would took hours before any practical action could be set into operation.
- In cases when pyromaniacs lay the fire, they choose forest areas, which are not approachable by vehicles and which are quite impassable and impenetrable, even by man. Also, they well use the weather forecasting and fires are laid down when strong winds are blowing. At such circumstances, the delayed wildfire alarm always results in a large environmental disaster and loss of property.
- The vehicles and equipment which fire fighters use in the region, at the time, are old and less effective and generally they often need hours to get equipment to the site and assure their proper service and mobility. In many cases, areas which are attacked by the wildfire in Dalmatian, do not have any direct access to water resources and fire fighters can only use airplanes and helicopters specially designed for the fire fighting from the air by use of surface water bodies, like sea or lake water available in the vicinity. Unfortunately, such kind of water taking can not be done safely during

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the dark. In the result, wildfire generally will widen to a larger area and most probably will become out of control.

- The fire risk factors are calculated globally for the whole area, using Canadian model based only on the meteorological data.
- There is no GIS supported information system for any kind of fire prevention planning, fire fighting management and planning after fire recuperation activities.

Every summer we all bear witness to superhuman efforts of the fire fighters in Dalmatian, particularly on the islands. Three biggest islands (Brac 395 km<sup>2</sup>, Hvar 296 km<sup>2</sup> and Vis 88 km<sup>2</sup>) in the Split and Dalmatian County have suffered in the year 2003. a number of large scale wildfires, which completely burned down and devastated about 1/4 to 1/3 of the total island area. Some smaller islands, like Bisevo (5,3 km<sup>2</sup>), were in 2003. exposed to wildfire, where total island's territory has been completely burned down. In all those cases the fire fighters and the territorial authorities could not stop the wildfire in time.

The state authorities, experts in the fire prevention legislation, fire fighter management, public- and private forest owners, territorial authorities, scientific institutions and technical universities researchers and technicians never came together as yet and never have shown the initiatives to constitute and build-up the fire prevention network. Such a network is necessary for exchanging data, ideas and experiences concerning passive and active measures of fire prevention. Such measures can in many cases prevent fire, or could send fire alarms of experts in time could enable on-line predictions of fire propagation in the real time, can set-up all organizational measures and could support the wildfire extinguishing plan.

### 3 HOLISTIC FIRE PROTECTION PROGRAM

At the end of 2003, for the first time in Croatia, the Authorities in Split and Dalmatia County together with University of Split (FESB) initiated the new holistic approach to fire prevention, fire fighting and post fire recuperation planning. The **Holistic Fire Prevention and Fire Fighting (HFPP)** program in the coastal region consists of diverse actions and measures like:

- thinning the forests by cutting and removing densely spaced trees, pruning trees and dragging dead and fallen-down logs, cutting shrubs and removing all kinds of ground wood residues, making thus forests easily passable and penetrable,
- clearing the forest corridors and easy access routes for fire vehicles and fire fighters,
- planning the necessary treatment of vegetation, in order to provide two kinds of fuel brake, where the first is designed to reduce the fire extension and the second limits the fire effects on the target, which could be a certain settlement or a group of houses in the forest vicinity,
- planning a new kind of "mixed land use" where forestry, cattle-breeding, agriculture, rural tourism, sport and recreation and health tourism motivate

the community to take more care on fire prevention measures

- planning the rain-water resources located on the land heights and hills, which is normally used in the agriculture and in case of fire, water is used to feed the extinguishing appliances,
- calculating in more detail the fire risk index for micro locations, using in addition to meteorological data also vegetation maps and fuel type data,
- 24-hour automatic video and on some places thermal monitoring alarm system with central collecting of video data for the whole region,
- 24 hours monitoring of local meteorological data (temperature, wind speed and direction, humidity, pressure and on some places sun radiation) using independent network of mini meteorological stations.

Such measures when systematically used as a part of an overall local and regional (passive) fire prevention management system can be very effective and could reduce the fire hazards to a value, which is about one third of the present fire risk.

The passive fire prevention means and measures, would reduce the overall fire risks, but can never substitute the expert management team, which takes over the command over the area under conditions of the natural disaster, like wildfire, floods etc. The well trained professionals having reliable up to date equipment, will help to decrease an attacked area and disaster consequences, as much as reasonably achievable.

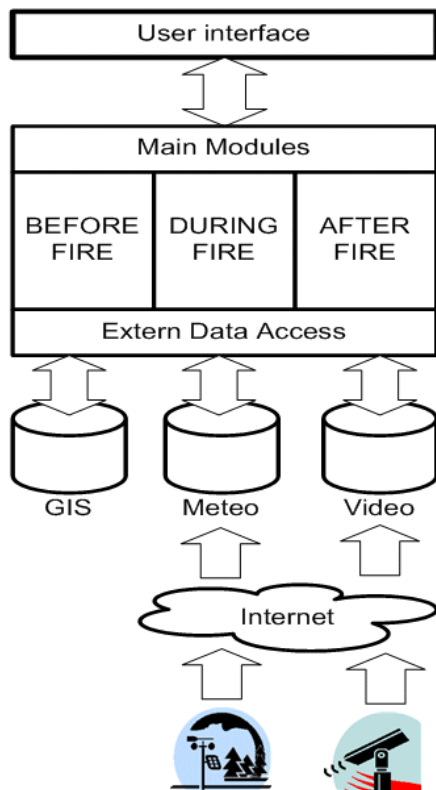
A lot of these preventive actions for fire protection are based on the early preplanning procedures. However, without the data base and effective information system such planning can not be optimal. As a part of holistic measures for fire protection in the Adriatic region, initiated by Split and Dalmatian County and University of Split, the information system capable to cope with preventive tasks must be fully compatible to the fire management system, as well as post fire planning of recuperation actions in the burned down areas.

On the European level there are a number of examples and efforts in this direction, but they are usually limited to certain tasks only, e.g. to fire risk calculation and forest fire damage assessment (Natural hazard project - EFFIS) [1], forest fire risk prediction and fire fighting management in Galicia [2], fire fighting optimization (project PIROMACOS) [3]. Ideas behind the project SPREAD [4] are most comprehensive. SPREAD project tasks include certain preventive measures, fire management and post-fire actions, so there are lot of similarities between SPREED and HFPP project. The main difference between the two programs is in the fact that HFPP efforts are primarily concentrated on the preventive actions, where the main goal is to find economically viable holistic approach in order to assure long term financing of such actions. This approach will be discussed in more details in the section 5.

#### 4 REAL TIME DATA PROCESSING SYSTEM FOR PRE-FIRE PREVENTION PLANNING, FIRE MANAGEMENT AND POST-FIRE RECUPERATION PLANNING

The overall system architecture is shown in Fig.1. There are three main layers:

1. External Data Access,
2. Main System Modules, and
3. User Interface.



**Figure 1:** Overall system architecture

The main idea is to construct the Internet based system, so that user interface could be any regular Web browser. All data are to be stored in Web data bases and used selectively by appropriate modules. The advanced architecture based on software agents is aimed for data acquisition, users request processing, data mining and data presentation.

Three types of data will be used:

a) **Online acquisition of local metrological data** – an independent module designed to obtain and store data in the Web data base. These data will be used for fire risk index calculation and for fire spread estimation, which is an input for the fire management system. We have already emphasized that this approach was deemed to satisfy more goals, like meteorological data, which will be also used for the agriculture tasks. For example, the local meteorological data base is a good platform for determination of optimal weather conditions for some agriculture activities like plant protection or similar.

b) **Online acquisition of video data** – an independent module designed to collect and store the video data into a photo Web data base. Images will be

used for the early detection of forest fires, based on the smoke detection during a day light and on the flame detection during the night. Images will be also used for the distant video presence in the fire management control room to overcome the difficulties of the near fire control.

c) **GIS (Geographical Information System) databases** – stores information on pure geographical data (elevations, road locations, water resources etc.), and all other relevant information related to a geographic position, like fire history, rain-water resources locations, land cover – land use, soil characteristics, local forest corridor map, tourist routes and similar. For fire prevention planning, this module is the most important part of the information system, which is due to a fact that almost all preventive planning activities are fully based on the GIS data base.

The three main modules (BF – Before Fire, DF – During Fire and AF – After Fire) build up the system core, where each of them collects the data from sub modules. The most important sub modules are:

1. **BF - Before Fire**
  - 1.1. Support for Evaluation of the Set of Prevention Planning Measures
  - 1.2. Early Forest Fire Detection
  - 1.3. Fire Risk Prediction
2. **DF - During Fire**
  - 2.1. Planning Actions in Fighting Fire
  - 2.2. Fire Growth Modeling
3. **AF - After Fire**
  - 3.1. Analysis of the Impact of Fire
  - 3.2. Evaluation of the Set of Measures Necessary for Recuperation.

The application of sub modules is not limited to the one task only. For example fire growth modeling will be used both, for preventive action planning using meteorological data from the data base and for fire management using real time micro location data.

In this paper we are concerned primarily on evaluation of the set of prevention planning measures.

The measures concerned with the planning are:

a) Planning the forest corridors bearing in mind not only the fire protection, but also tourism, using forest corridors as mountain bicycle routes, or agriculture like revitalization activities in certain areas.

b) Planning the position of video monitoring systems and location of mini meteorological stations.

The GIS data base, particularly the 3-D modeling of a terrain is of the primarily importance. The first step in establishing the GIS data base will be to collect all relevant up to date GIS data for Split and Dalmatian County, including all County's neighboring land areas.

Fire prevention measures must be thorough and very extensive. If fire prevention measures are to be fully effective, the total area under the fire protection must be included. The included area must therefore contain also those areas, which hereto never were exposed to the wildfire. Large scale thinning of forests, clearing the forest corridors, treatment of vegetation, activating of

agriculture and preparing the water resources on the hills, suppose that extensive work could be adequately paid and thorough done by residential population, which could also open many new working places in the region.

## 5 COMMUNAL CHP PLANTS BASED ON WOOD BIOMASS AND TOURISM SUPPORT FINANCING OF THE FIRE PREVENTION

The clue is to use the residential population (very extensive) work for collecting biomass from the local area and use it locally in the combined heat and power (CHP) plants, which supply the district by energy carriers, like heating, hot water, cooling and electricity, which are transported to distances from 5-25 km and thereafter locally distributed to their end users, by means of piping networks and national (or local) electrical grid. The primary energy source, which is needed to feed the communal energy plant, shall be covered to a large extent (depending on the locally available quantities of wood fuel) by renewable energy sources, like biomass and solar energy. Local solid biomass shortage is only temporal, because in time periods of few years only, a plantation of young trees could cover the energy demand. Meanwhile, LPG could be successfully used to bridge the short-term wood fuel shortages.

The total present heating and cooling potential in Split and Dalmatian County is about 3 TWh/a for households and tourism. In the concept of district heating and district cooling (DHDC), about 60% of thermal demand was supposed to be covered by biomass and the rest of 40% demand can be covered by solar energy in the region. Under such assumptions about 2 TWh/a was supposed to be covered by biomass, and the rest of about 1 TWh/a could be covered by 1,2 million sq. meters of solar collectors. The solid biomass (wood) volume, needed to feed the local CHP DHDC plants in Split and Dalmatian County, which covers the thermal energy demand of 2 TWh/a, was assessed to about  $10^6 \text{ m}^3$  of conifer wood fuel per year, which is about 6 times the wood volume, which was burned down in the year 2003 in wildfires in Split and Dalmatian County.

The sale value of delivered thermal energy of 2 MWh/a was assessed to about 130mill.€/a. The total investment in solid biomass CHP plants in Split and Dalmatian County, having in total an estimated thermal capacity of 500 MW<sub>t</sub>, including transmission and distribution network, are appraised at the order of 600 mill.€. The yearly wood fuel costs are estimated to 20 mills. €/a, which is deemed to cover the yearly labor, overhead and equipment costs for the fire prevention. The total investment including the financing costs can be paid back in a time period estimated in the range of 6-8 years.

The forest corridors, easy access routes, passable and penetrable forests, make possible foresting, agriculture, cattle breeding, and also some new forms of commercial tourism, like rural-, recreational- and health tourism. Also, these activities will offer a plenty of new opportunities to families to build-up their existence for the years to come.

The last, but not the least, the wind potential, in particular on the islands, can be used not only to supply

electricity to the end users, but also will be used as a permanent source of renewable energy for pumping stations, by pumping the rain-water to water storages on the hills, which can be used for agriculture, cattle-breeding and fire protection.

## 6 CONCLUSIONS

Many areas covered by forests in Split-Dalmatian County and in particular coniferous forests on the islands Brac, Hvar and Vis are mostly not approachable by vehicles, commonly the forests are impassable and impenetrable, even by man. Last years, Dalmatia much suffered from forest fires in the summer time. The total in the summer 2003 burned down wood mass of 35.000 m<sup>3</sup> in Split-Dalmatian County, which expressed in energy equivalent amounts to 320 TJ, could have been used for heating of 10.000 households.

The present work describes activities and evaluates effectiveness and economics of the preventive fire protection measures, like (a) 24-hour electronic (infrared and video) monitoring, (b) collection of forest loppings, cut timber and chopped wood to be used as a biomass fuel in communal district heating and cogeneration plants, and (c) clearance of forest corridors as easy access routes for firemen in case of fire, where at all other times same routes are available for sport, recreation and village eco-tourism.

The aim of task (b), based on the private-public partnership was conceived for two purposes, (1) to animate and make financially attractive for local inhabitants collecting of loppings, chopped wood, dry trunks, and other biomass resources on the massive scale, in order to be used as a fuel in cogeneration and heating plants and (2) to thin forests and keep the wooded area as clean and passable as reasonably possible.

Lot of these preventive actions are based on planning, which without effective information system can not be optimal. Therefore, the authorities of Split and Dalmatian County initiated the more complex holistic approach to fire fighting, unique in Croatia, based on the information system for planning fire prevention, early detection of fire, fire fighting management and post-fire planning the recuperation of the burned-down areas.

As a result of these activities fewer fires are expected in Split and Dalmatian County. Also, a number of direct and indirect value added effects will be experienced in the local economy.

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