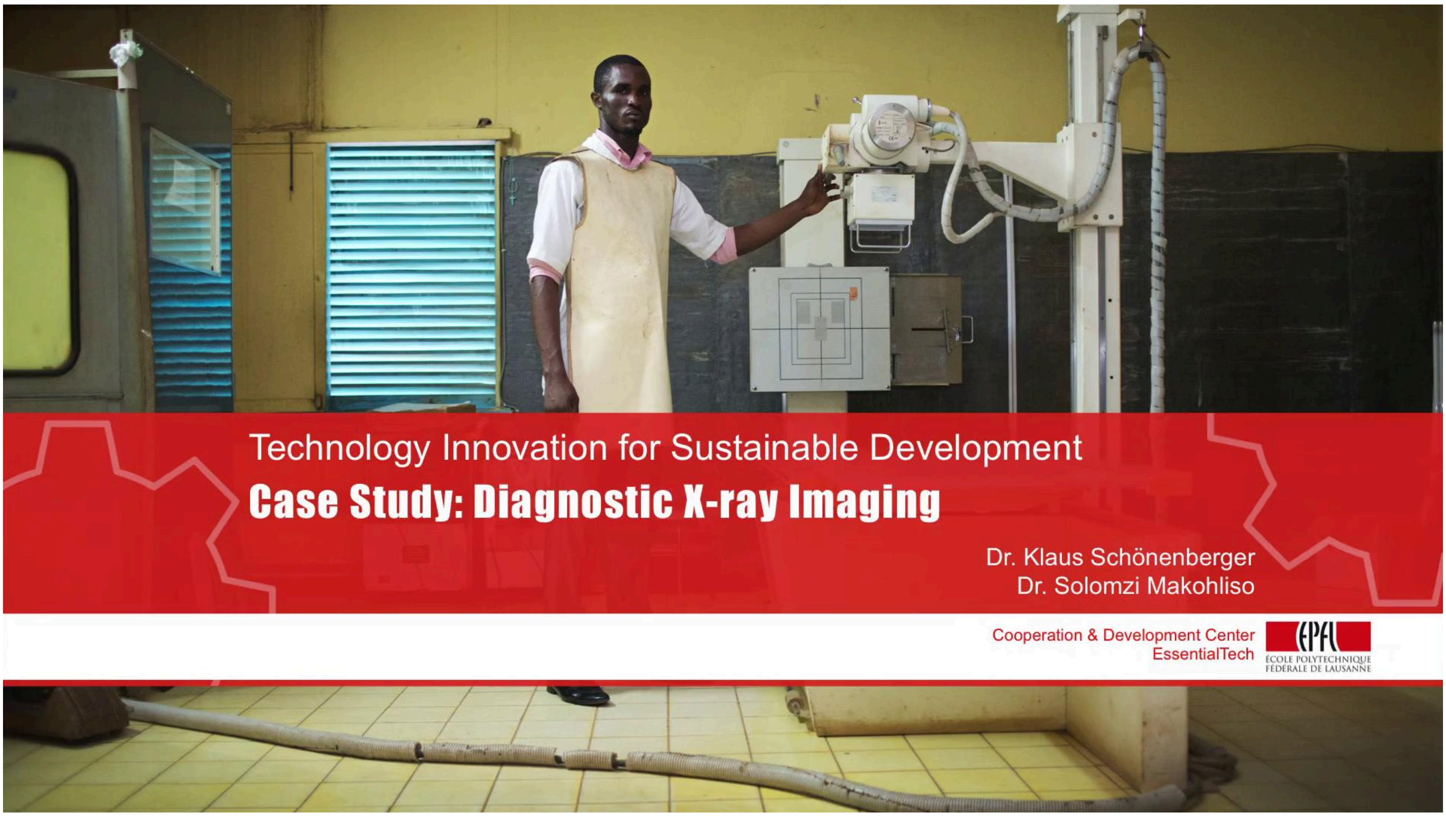
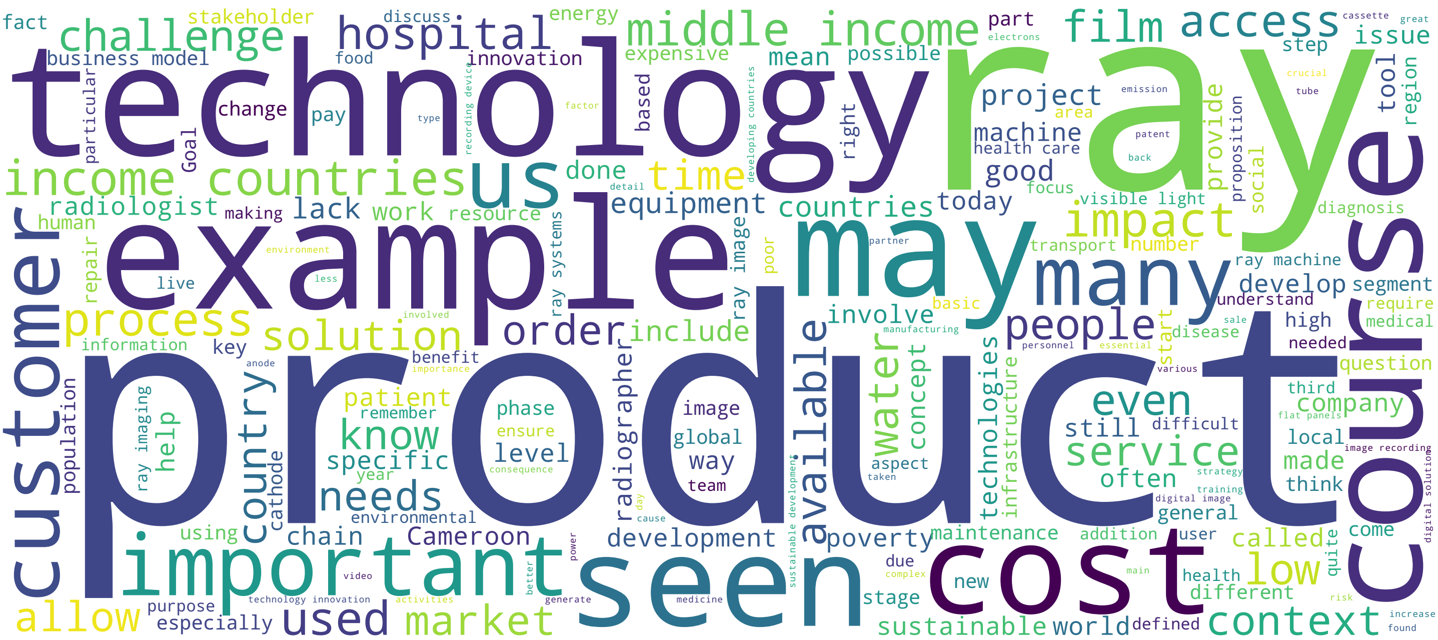




Search MOOC

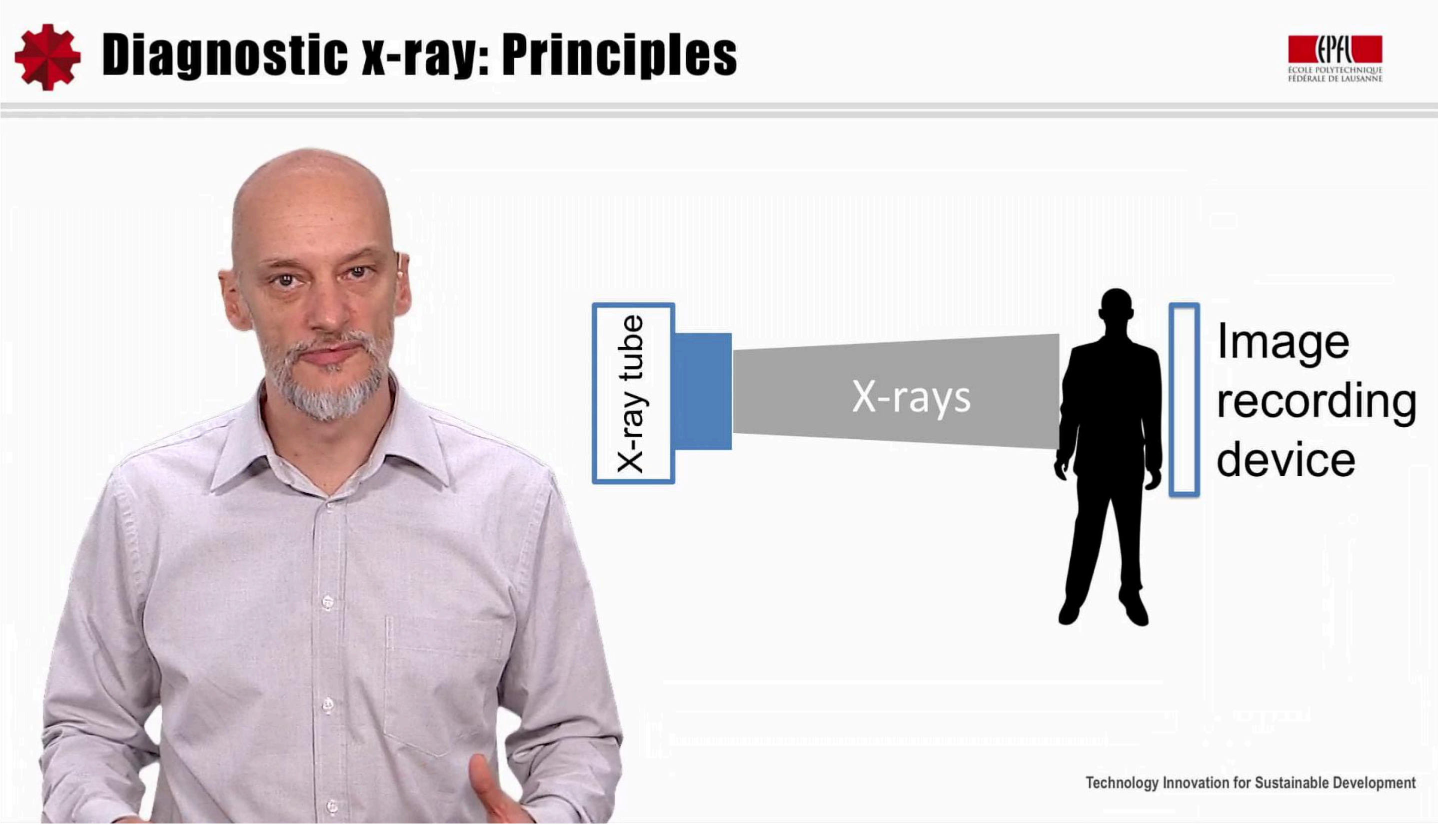
Video

Hello, in order to better illustrate this course and especially the chapters describing the methodology, we need to introduce a practical example. We have decided to focus on diagnostic imaging and specifically on radiology. In this video we will explain what is radiology and why it is needed. However, we will only give you the very basic information on X-ray radiology that we need to be able to illustrate the concepts. It is not the purpose of this course to give you a complete presentation on this topic. Those of you who are interested to learn more will find additional material on the website. Let us start by having a brief look at the invention of this technology Wilhelm Conrad Röntgen was a German physicist born in 1845, he was the first to discover a new type of rays, 16 00:01:15,838 --> 00:01:17,529 which he called X-rays. He was awarded a Nobel prize in 1901 for his discovery. In the picture on the right, you can see the very first X-ray image of a human body part. For instance, showing his wife's hand wearing a nice ring. When she saw her skeleton she was shocked and she exclaimed "I have seen my death!" This picture was taken in 1895 well over a century ago it marked the birth of medical radiology. Let us now see how X-rays are used in medicine.

Notes

Summary

0m 22s

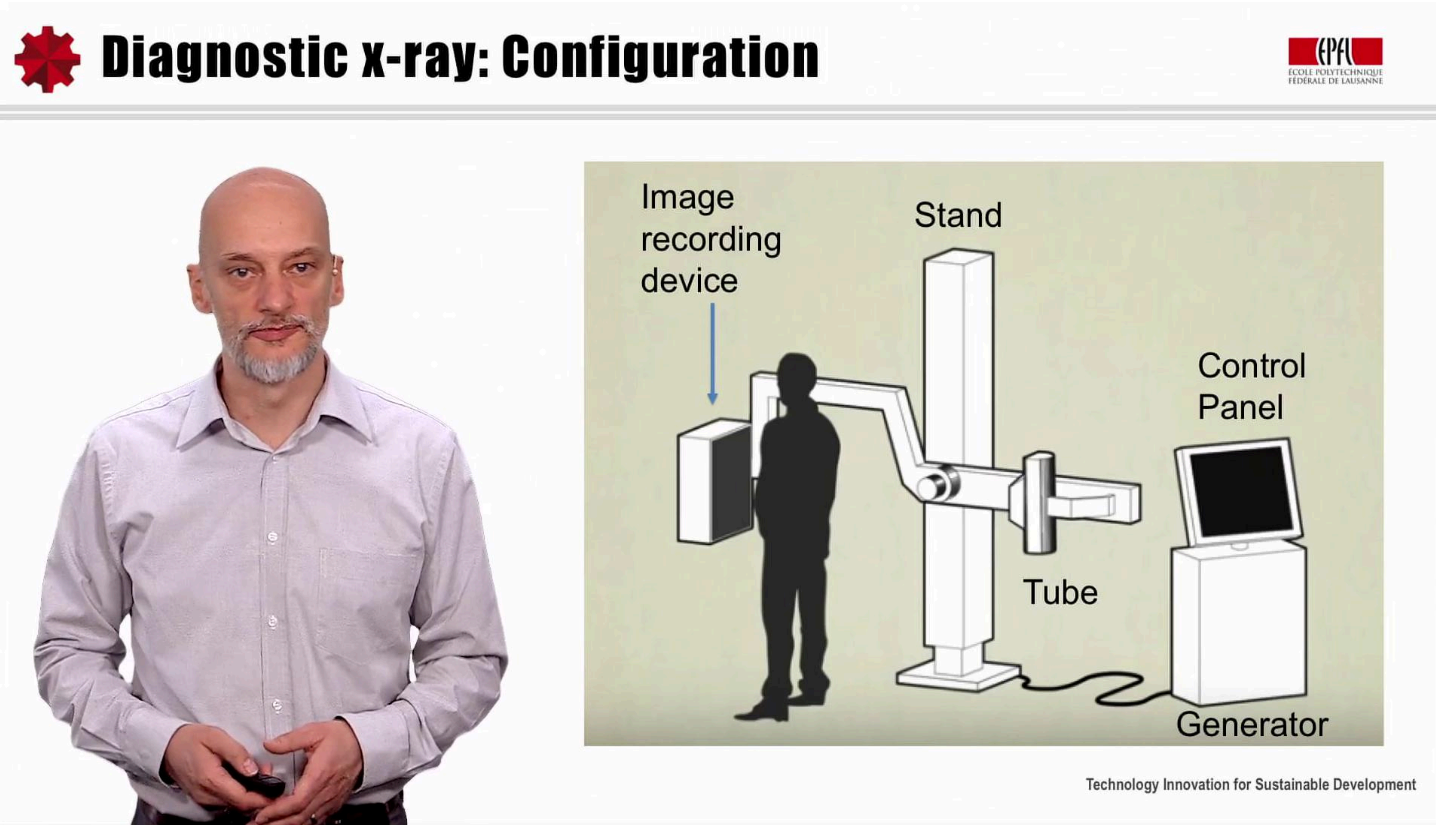


X-ray is a high energy ionizing radiation which can travel through human tissue, where it can be more or less absorbed depending on the tissue's density. For example, bone tissue has higher absorption than soft tissue, such as the lung. More generally, materials with high atomic numbers have high absorption properties. Lead, for instance, has a very high atomic number and is thus used to block X-rays, which, due to their ionizing properties can potentially be harmful for humans. X-rays are generated in a vacuum tube, shown on the left, in this tube there is a cathode and an anode. The cathode, which is a tungsten filament, is heated up with an electric current. When enough energy is transmitted to the cathode's atoms some electrons will be emitted through a thermal ionic effect. If we now apply a large voltage difference between the cathode and the anode, typically 40 to 100 kilo-volts, the electrons will be accelerated at a high speed away from the cathode in the direction of the anode. Once they hit the anode, the electrons are slowed down by the anode material, which causes the emission of X-rays. The process requires a lot of power as only 1% of the energy is effectively transformed into X-rays and the rest is lost as heat.

Notes

Summary

1m 52s

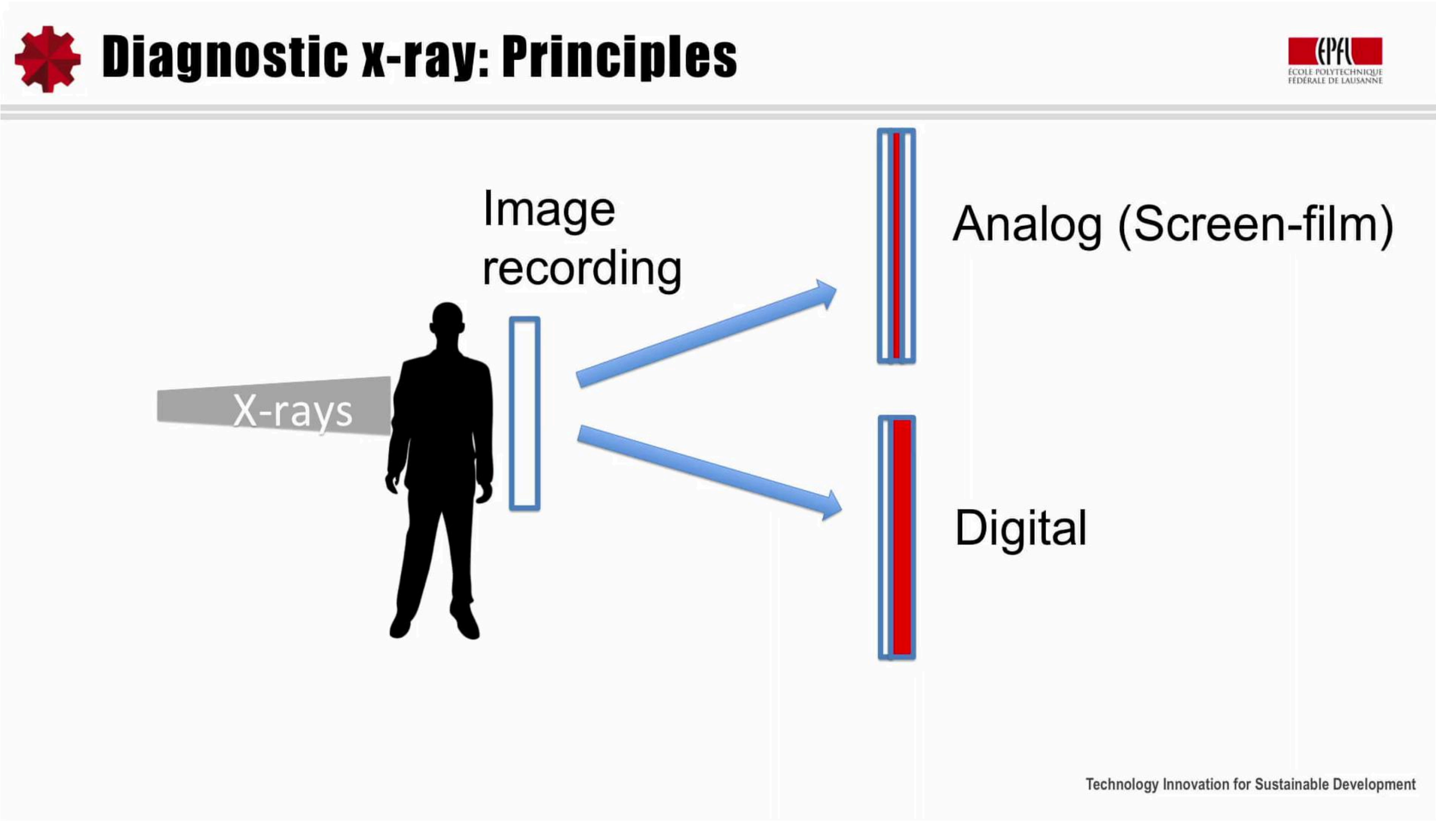


There are several different configurations of medical X-ray systems. In one frequently encountered configuration, the tube is mounted on a stand with a swiveling arm, such as the one shown here. This configuration allows to ensure that the tube remains aimed at the image recording device at all times. The system also includes a power generator and a control panel. In an other configuration, the tube is mounted on a pointing device attached to the ceiling or to the floor, with a rail system to enable moving it around. Some systems include a table where the patient can be examined in a lying position, and where the image recording device is integrated. Finally, there are also mobile systems on wheels, which can be moved to the patient's bedside.

Notes

Summary

3m 29s

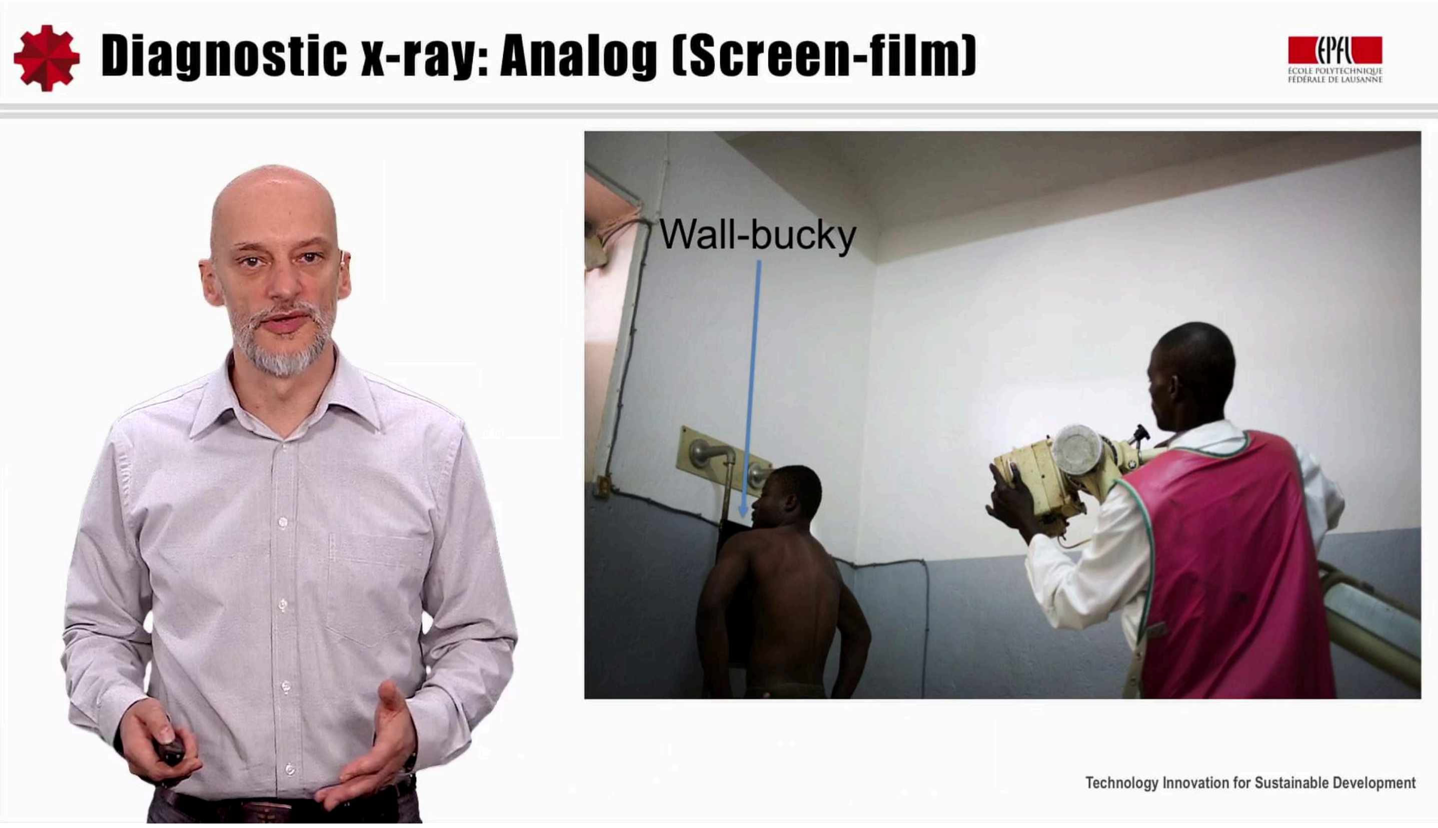


Let us now go back and talk about the image recording device. Once the X-rays have traveled through the patient's body they have to be transformed into an image that the radiologist can see. This can be achieved basically with two different processes, which are both still in use today. In the first process, the X-ray image is converted into visible light by means of a screen placed close to a photographic film, this screen is made of special crystals and it is also known as a scintillator screen. When the X-ray beam containing the patient's image hits the screen, visible light is emitted, which exposes the photographic emulsion of the film. The film on the screen are located inside a tightly closed frame called a cassette. The second technique generates a digital image directly, there is no film involved. Let's look into these two techniques in some more details.

Notes

Summary

4m 22s

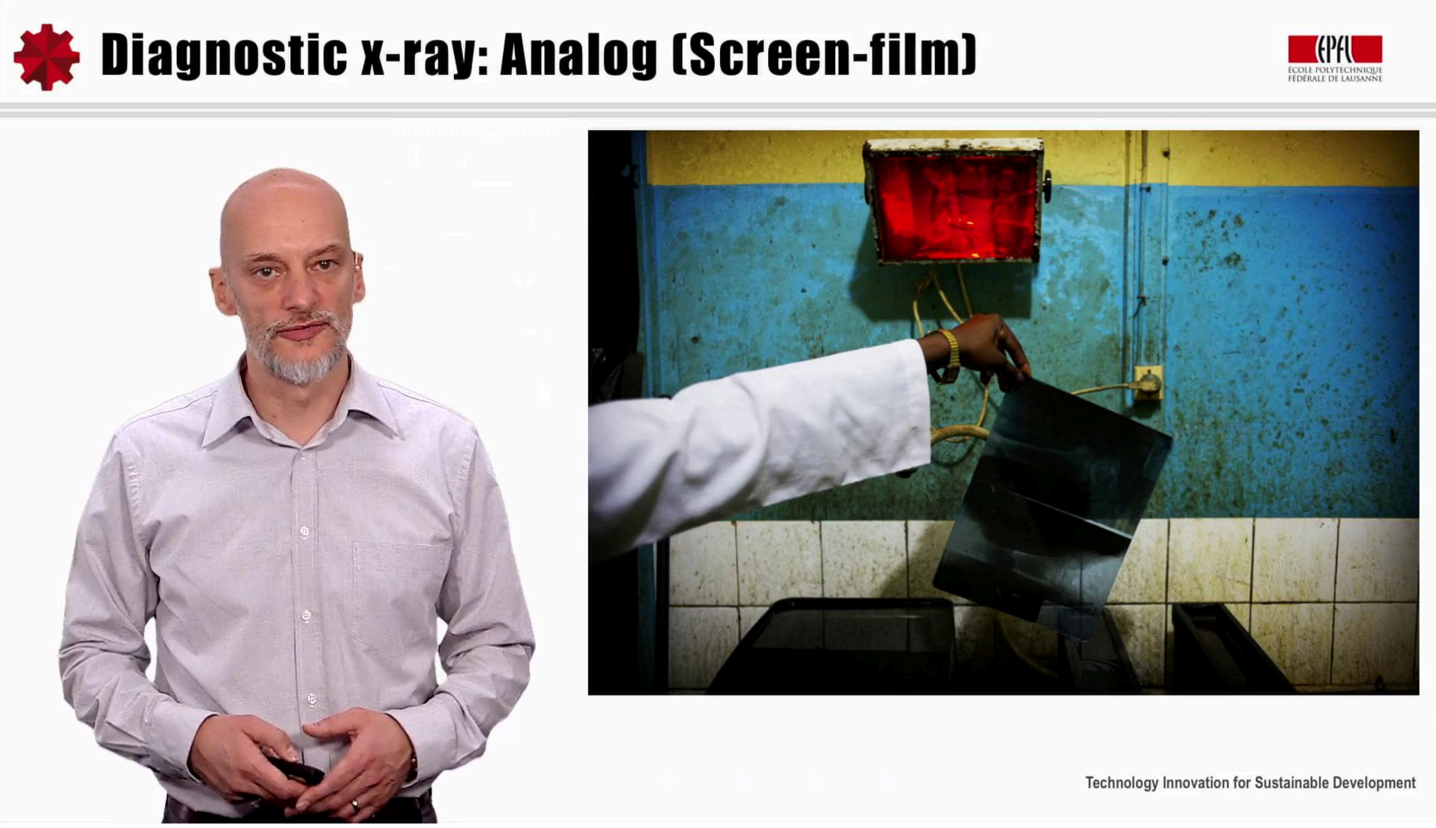


Here you can see a chest radiography being taken in a hospital in Cameroon, as you can see the radiographer on the right is wearing a protective lead apron. Here, he's using a mobile radiography system. Note that one has to distinguish between a radiographer and radiologist, these are two different jobs. Basically a radiographer is a technician trained to make radiological images and the radiologist is a medical doctor trained to interpret the images with the purpose to come up with the diagnosis. The patient stands in front of what is called a "Wall-bucky", where the cassette with the film is located. The radiographer aims the tube at the patient and exposes the film. Once this is done, the cassette is retrieved and taken away for development.

Notes

Summary

5m 20s

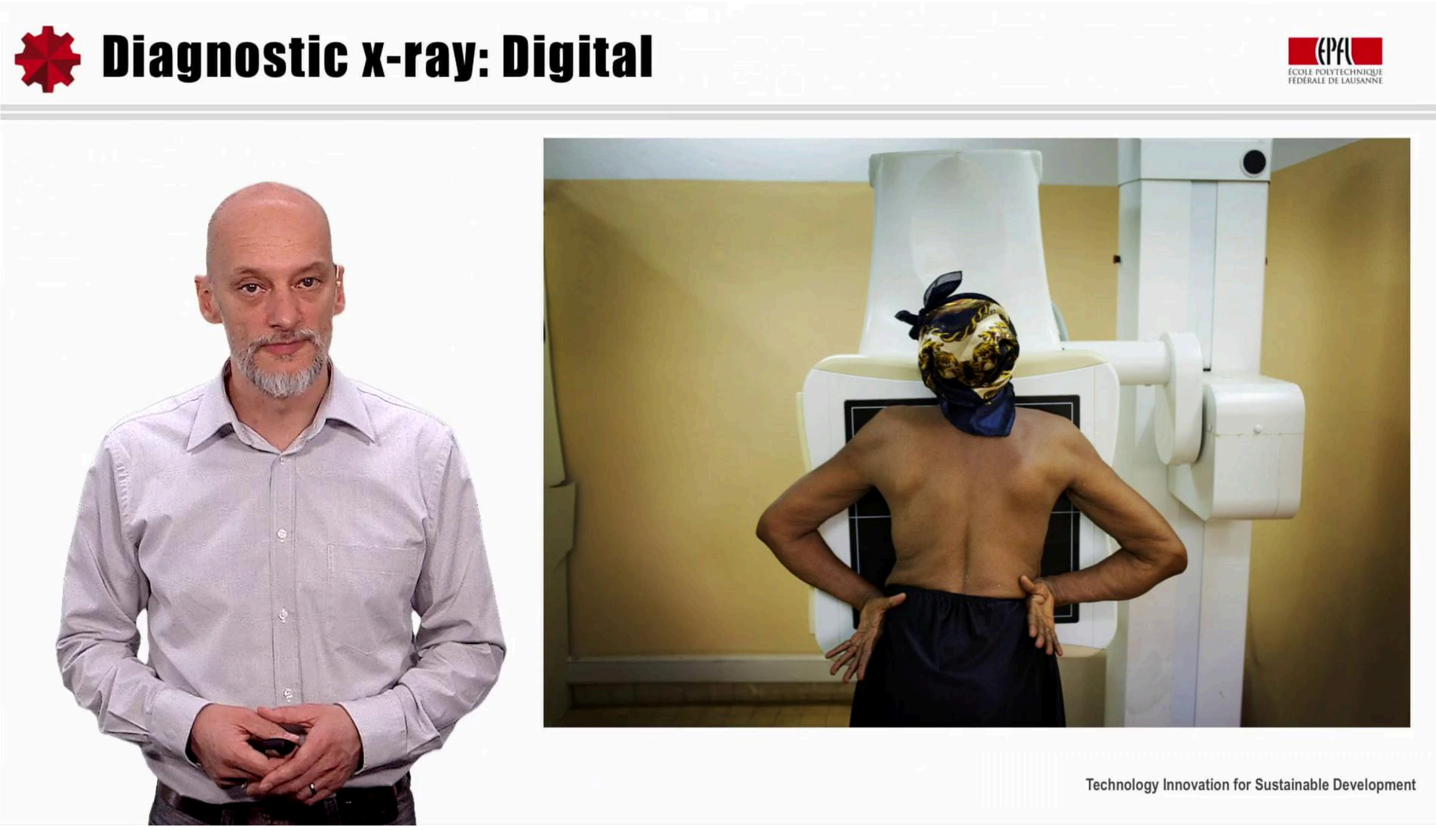


The processing of the film usually involves steps of developing rinsing, fixing, washing and drying. This must be done in a dark room and involves the use of specific and toxic chemicals. The timing and temperature of the process need to be controlled precisely, otherwise the image quality will be degraded. The film can be processed either manually or automatically, using a film processor, in which case there is no need for a dark room but the processor requires electricity and maintenance. For either manual or automatic processing the total cost of the film and chemicals needed for one image is around 3.50 US dollars. In many low and middle income countries the patient will also have to pay for the diagnosis itself, which can typically cost 15 US dollars.

Notes

Summary

6m 13s

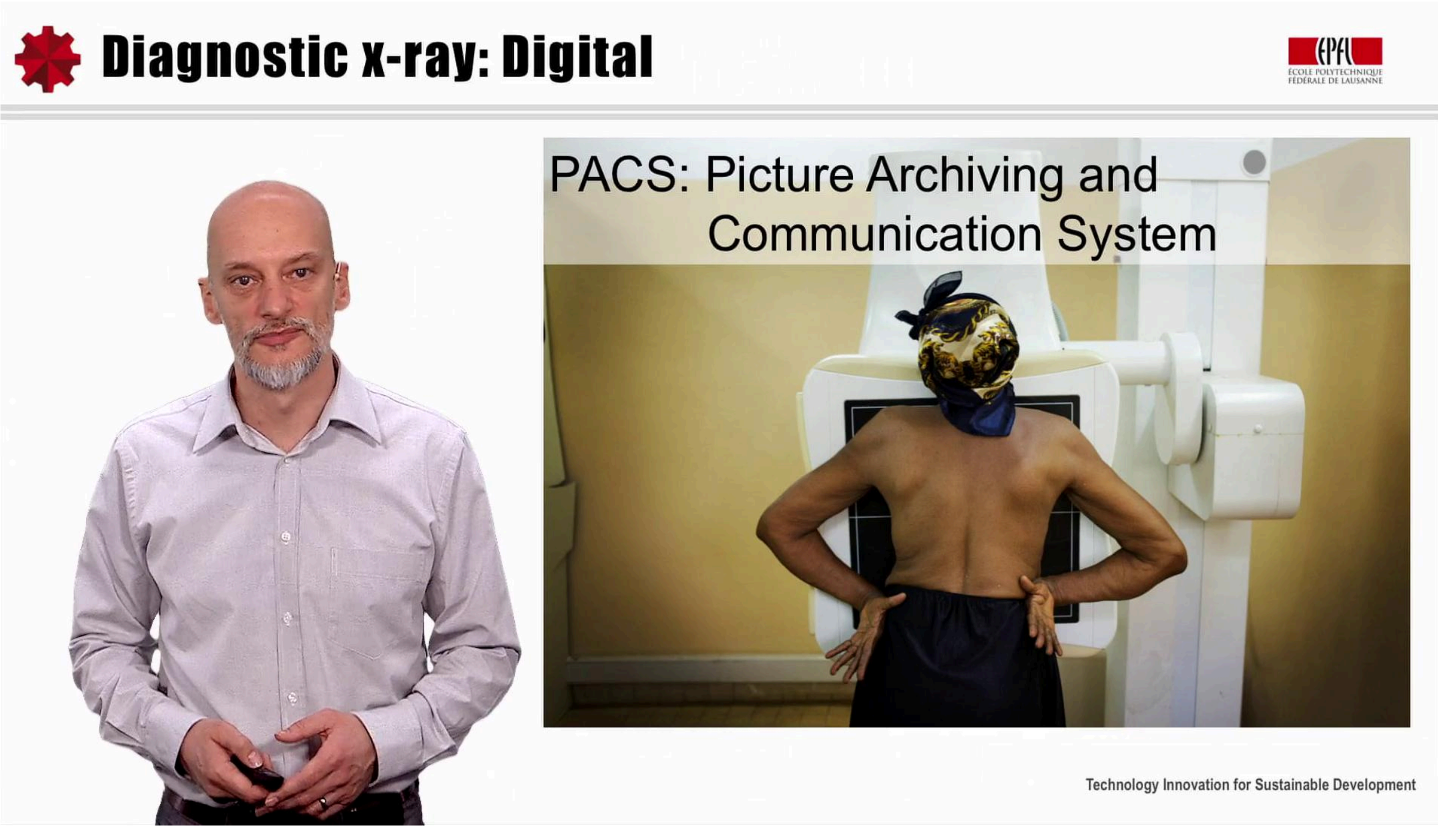


In a digital imaging process the film is replaced by a photo sensitive detector. The technology involves a conversion of the X-ray image into either visible light or charges that can be captured by some electronic sensor. The current state of the architecture technology relies on large detector plates called flat panels. The detectors have exactly the same size as the image they capture, because it is very difficult to focus X-ray beams. In the detector, a layer of scintillator material converts the X-ray into visible light. Directly behind the scintillator layer is a sensor array of which each pixel generates an electrical signal in proportion to the light received. This electric signal is encoded in order to produce an accurate digital representation of the X-ray image. Flat panels have the disadvantage of being very expensive and fragile, in addition, their performance degrade quickly when temperatures increases above 27 to 30 degrees celsius. There are other types of X-ray imaging devices based, for example, on CCD or CMOS detectors, which are similar to the technology that can be found in your digital cameras. They tend to be more cumbersome and less sensitive to X-ray radiation than flat panels.

Notes

Summary

7m 12s



Sensitivity is an important parameter, because due to the potentially harmful effect of X-rays, one has to limit the patient exposure as much as possible. while still being able to generate a good image. Being able to process, store, review, and transfer digital images is certainly a great advantage, this requires a so called PACS, which stands for: Picture Archiving and Communication System. The PACS also allows to manage the workflow of patient exams. In modern hospitals, the radiographer can take an image in some location and the radiologist can review it on a workstation located elsewhere. As a a consequence, a PACS generally requires that some information and communication capabilities are available in the hospital.

Notes

Summary

8m 33s

In summary

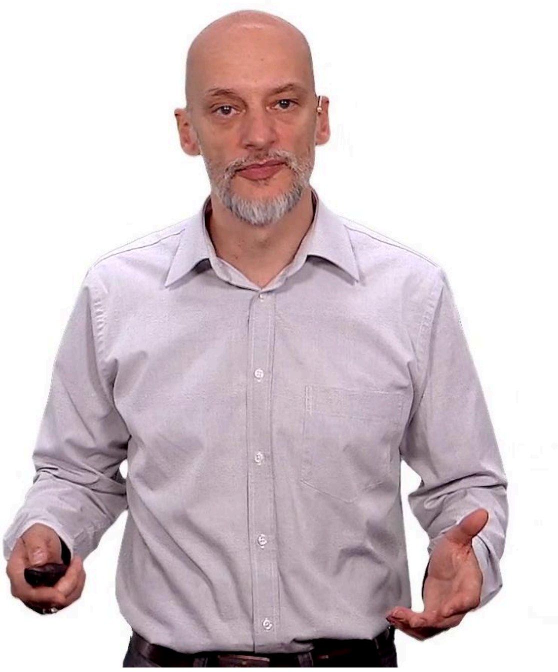
In summary, let us say that analog film screen is still very much in use today, and overwhelmingly so in low and middle income countries. However, like in film photography, it is a technology that will most certainly disappear in the future. It's main disadvantage is the fact that it relies on consumables, such as films and chemicals for development, which can be difficult to obtain. In addition, while the purchase cost of the system itself is quite low compared to digital solutions, the recurring cost of those consumables makes this quite an expensive solution in the long run. Finally, it is a slow technique which requires quite a bit of know-how to be able to make good images.

Notes

Summary

9m 21s

In summary



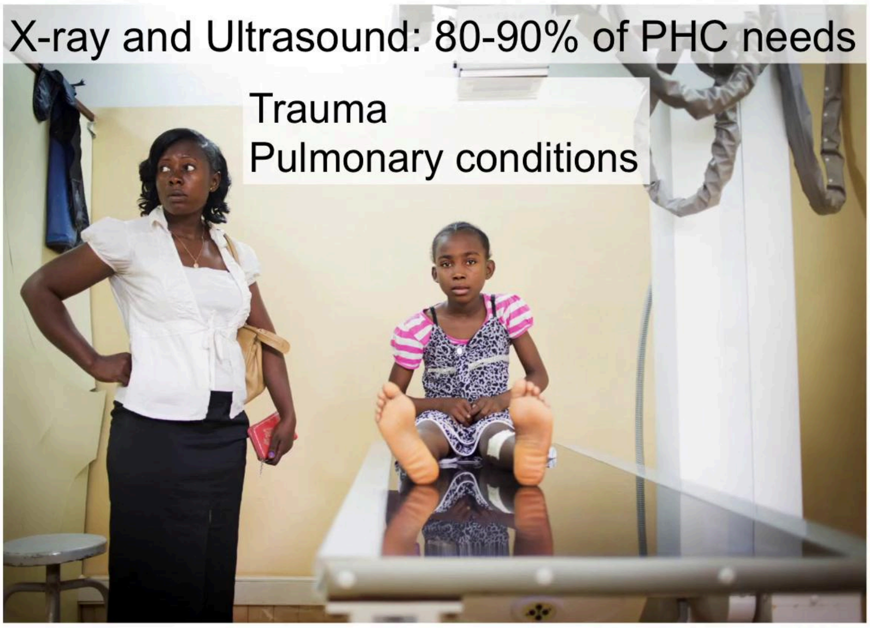
Digital solutions are more expensive to purchase and more complex to use and maintain. Due to the increased complexity, the need for maintenance, and calibration, are also increased, which requires skill and resources. The great advantage is, of course, that the image can be easily transferred over the internet, the flip side of the coin is that this requires access to information technology, which may not be available. The cost of making a digital image is virtually zero, and the acquisition time is a couple of seconds, which allows to increase the number of patients diagnosed per day.

Notes

Summary

10m 11s

Diagnostic x-ray: Importance



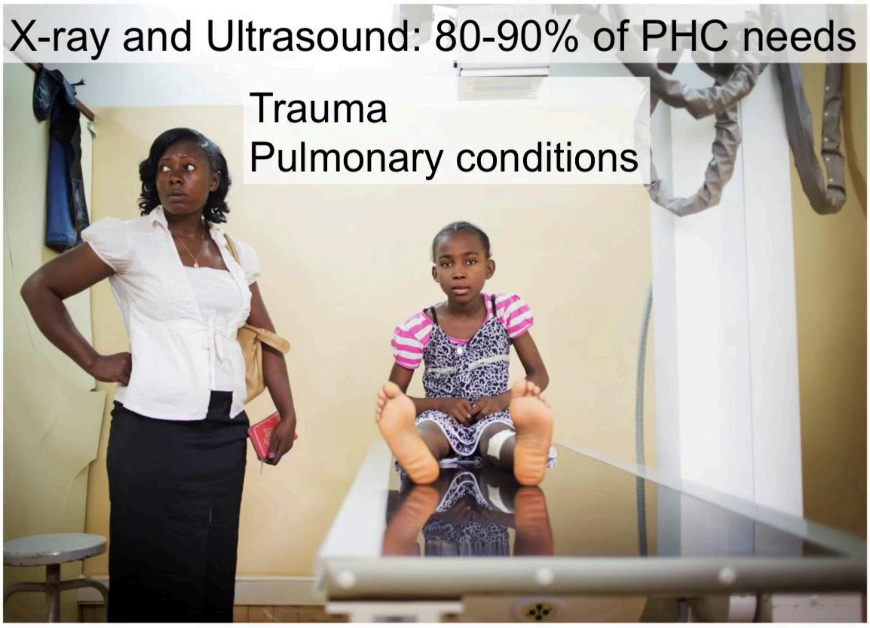
Technology Innovation for Sustainable Development

Finally, in both cases, adequate training is essential for three categories of personnel. The first is for medical doctors or radiologists to able to interpret the images, the second is for radiographers to be able to make good quality images and in a safe way, the third is for technicians to be able to service and maintain the system, as well as the related infrastructure. Now that we have seen the basics of medical X-ray imaging, let us discuss it's importance in health care. According to the World Heath Organization, X-ray radiology together with diagnostic Ultrasound, cover 80% to 90% of the needs for diagnostic imaging in general. X-ray, in particular, is very much used for diagnosing trauma. As we have seen in a prior video, road traffic accidents are very frequent globally, There are about 20 to 50 million victims of road accidents every year and 90% of them live in low and middle income countries. Another crucially important application of X-ray imaging is for the diagnosis of pulmonary conditions. Tuberculosis, for example, still represents a huge problem worldwide. According to the WHO, in 2015, over ten million people fell ill with TB and 1.8 million died from the disease.

Notes

Summary

10m 54s



Technology Innovation for Sustainable Development

Over 95% of TB deaths occur in low and middle income countries. There are many other uses of diagnostic X-rays such as: orthopedic conditions, foreign bodies or cancer. This is really an essential modality in medicine, but how available is X-ray on the global scale?

Notes

Summary

12m 25s

The World Health Organization estimates that over two thirds of the global population lack access to safe, reliable and competent radiology services. This is a shocking number and even more so when we take into consideration that this technology was invented by Röntgen over 120 years ago. This technology is a great example for our course. It really epitomizes all of the five challenges which we encounter in the context of low and middle income countries, and which we have seen in a previous video. The first challenge, as you remember, is a lack of quality infrastructure, X-ray machines can consume a lot of electrical power, typically between 30 to 50kW In many hospitals we have seen, the available power is barely enough to cover just the power needs for the X-ray system alone, let alone other needs, such as lighting. The facilities where the X-ray system is located often also lack adequate protection against harmful radiation. Finally, the quality of the water needed to develop the film is often below standard, due to poor quality water supply infrastructure.

Notes

Summary

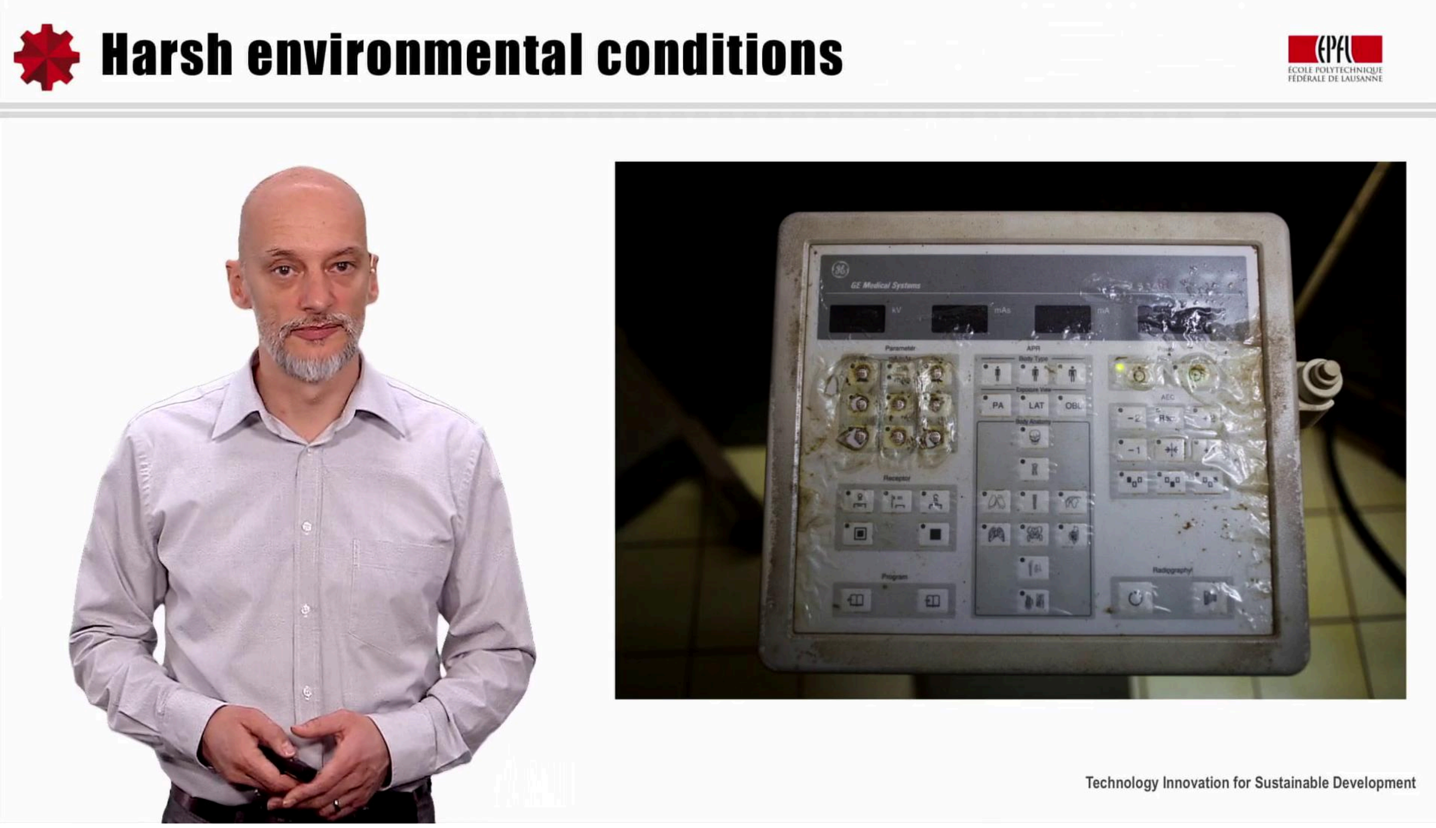
12m 45s

The second challenge of the context is the lack of financial resources. The cost of some X-ray machines can go from US$20K or US$30K for a film screen system, and US$100K to US$200 for a complete digital solution. This is far too expensive for most primarily health care structures. In addition, since regular maintenance is usually needed, maintenance contracts over a ten year lifespan can easily cost as much as the initial purchase price. Sadly, one has to mention that most manufacturers won't assure maintenance in remote places anyway. For these reasons, X-ray systems which are found in low and middle income countries are often donated second-hand obsolete devices.

Notes

Summary

14m 06s



In Cameroon, which is a lower income country with a population of roughly 20 million, less than 10 radiologists are trained every year. There is also a permanent lack of trained radiographers and biomedical technicians. Even when simple maintenance or repairs are needed, it is unlikely that anything can be done locally due to this problem. The lack of trained personnel is our third challenge, as we have seen. This is the control panel of an X-ray system in an African hospital. As we can see, it was not designed to resist the harsh climate found in these contexts. Harsh environment is our fourth challenge. It takes a heavy toll on X-ray machines, with little possibilities for repairs, as we have seen.

Notes

Summary

14m 57s

Poor governance

Our last challenge is poor governance. In the case of X-ray technology, we have heard of many cases of corrupt local representatives of X-ray manufacturers or maintenance companies appointed by the manufacturers. These organizations sometimes request huge bribes from hospitals, in spite of existing and already paid up maintenance contracts. Also when X-ray systems are purchased, this is mostly done through tenders, due the high amounts of money involved. This is an area where corrupt practices are very frequent. Now that we know more about the lack of access to radiology, how can we approach such a problem and develop a sustainable solution? We will try to respond to that in the remainder of this course. Goodbye.

Notes

Summary

15m 49s